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FORMATION OF THE EARTH.

THE DYNAMICAL THEORY OF THE FORMATION OF THE EARTH,

BASED ON THE ASSUMPTION OF ITS

NON-ROTATION

DURING THE WHOLE PERIOD CALLED

"THE BEGINNING."

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INTRODUCTION.

MANY years have elapsed since the fundamental principles of the Cosmographical Theory, whose development occupies the following pages, presented themselves to my mind.

Some of these have been passed under a tropical sky, and others in the more cloudy and sombre regions of my native land; vicissitudes of circumstances, and changes in life, and, consequent thereon, variations of mental habitudes have intervened—indeed, have intentionally been permitted to intervene—in order that, by every possible test, I might prove the soundness of the remarkable but indestructible conclusion to which my earlier studies had led me—namely, THAT THE EARTH DID NOT ALWAYS ROTATE AROUND ITS AXIS.

In estimating the effect which this announcement is likely to produce on the minds of others, I have considered that, naturally, as much, probably much greater reluctance will be experienced by them in admitting this truth than what I myself experienced when first it presented itself to my imagination—when I even shrunk from it, as if it had been a monstrous lie, seeking to insinuate itself amongst the simpler and more obvious lessons which I had been taught by philosophy!

The remembrance of these impressions, and of the anxiety I then experienced, when called upon, by its importunate recurrence, to make my election—to admit it at once, or to thrust it away from me entirely—induces me now, to be considerate when similar prejudices arise in the minds of others; and in all my arguments, to select such evidences as may be best adapted for removing every obstacle, and making way for the reception of this important truth, and of all those others, which, as natural consequences, emanate from it; while, on the other hand, I trust that henceforward the erroneous dogma of rotation *ab initio*, with all the errors into which it has led us, and has been the means of perpetuating, may be entirely swept away, never to re-appear.

Withal, I am fully aware that it is extremely difficult for the inhabitants of a world, wheeled round by its diurnal motion through space, and constrained to take this elementary motion into all their calculations, to believe that it was not always so—*that there once was a period of non-rotation.*

Those, who from the moment they open their eyes on this fair earth, perceive the light of the sun, and grow up under its cheering and fostering influences, will most reluctantly give themselves up to the persuasion that there once was a time—a period of long duration, when the central orb afforded no light, and when the earth recognised it only as the convergent centre of attraction—the great sustaining counterpoise which enabled it to revolve through unillumined space.

It is no easy task to persuade mankind that the sparkling, briny seas, which are now so easily excited and lashed into foam by the ambient atmosphere, were once a dark, unruffled, and atmosphereless mass of turgid waters, charged to repletion with the mineral elements of those stony concretions which now engirdle the terraqueous globe, and have been thrown up, as barriers, to restrain the very waters from whence they themselves were deposited.

Nor is it a less arduous undertaking to convince those who delight in the invigorating influences of the health-giving atmosphere; that, for ages, this sphere existed without so indispensable a means of sustaining voluntary motion—and that myriads of apulmonic creatures, "more numerous than the sands on the sea shore for multitudes," were, all the while, employed as the humble and submissive agents of the Creator, in producing one of its component elements; in elaborating *that*, without which no being, endowed with the faculty of locomotion, could either have breathed, moved, or lived.

All these, nevertheless, are truths; truths of the utmost importance. Of this, the perusal of the following treatise can hardly fail to convince every unbiassed mind, even although my relative position towards the world's inhabitants involves the alternative, either that I am in a trance; have been for so many years enjoying the most soul-satisfying dream, during which the records of revelation have appeared to be at one with the discoveries of science, and to have kept pace with these wherever they have been made, where every closed lock seems to undo, and every barred door to fly open, on the announcement, *that there once was a period when the earth had no rotation;* or, on the contrary, all mankind have been in a profound slumber, as regards this important fact, for nearly six thousand years! This is our true relation to each other at the present moment. But it is full time that the spell should be broken, and the rightful position of each should be justly determined.

With this intention, responsible as it is to stand against the arrayed opinions of a whole world, I have resolved to be the first to break this long-continued silence, and endeavour to prove, that I have been entertaining no day dream; but that what I assert is true, and stands upon the authority of the immutable word of God, from which, assisted by the discoveries of science, there can

be derived the necessary data to prove, that during the period called in Scripture "the beginning," THE EARTH HAD, IN REALITY, NO ROTATION AROUND ITS AXIS.

With respect to the scientific evidences, I take occasion to premise—what will very soon force itself upon the reader's notice—that they are taken from the writings and the researches of others: whatever merit attaches to them, belongs exclusively to their authors, not to me. Mine is to be regarded merely as the mind through which these matured truths have been made to pass; and by which they have been arranged, combined, and applied according as, I believe, they were designed to be, by the plan of creation; traced out from all eternity; progressively but slowly developed for many ages, but rapidly unrolled during the first six days of the Mosaic week; when the whole was finished, and made a glorious and a perfect fabric, in which even the all-searching eye of Omniscience could discover no defect, but by Him was pronounced to be "good."

The jeweller pretends neither to have *made* the orient pearls, nor to have formed or discovered the sparkling gems of which *his* work consists. Their proper selection, their arrangement, and the workmanship of setting them are alone his. So, in like manner, I disclaim all pretension to be the maker of those jewels of nature. *Natural truths*, which, like beauteous pearls, cannot be made by man; although man's industry, in either case, is required to bring the objects of his enterprize from underneath the depths to the light of day, to remove whatever conceals them, and to display them to the admiration of the beholders.

Neither do I pretend to have discovered, to have wrought up, or to have polished any of those radiant gems—*residuaries of ancient organisms*—which the intelligence and assiduity of scientific naturalists have happily enabled them, in these latter days, to find; and which they have, with so much skill, extricated from the embedding rocks, and fitly framed together, until they have stood forth in perfect truthfulness, in all their endless variety of strange and uncouth forms; shedding upon an astonished world the almost bewildering light of antiquity; of an incipient creation!

To none of these achievements are any pretensions put forth. But *I do* pretend to have discovered an ancient and a massive crown—once the glory of all—from which, by neglect, these beauteous gems and costly pearls have been allowed to fall; and to have found, besides, a casket containing abundance of fine gold and of silver seven times purified, wherewith to repair the crown, and to reset the jewels. And ever since these discoveries were made, I have wrought assiduously—to replace those ornaments of inestimable value which conferred upon it so much lustre; and to restore it to all its former splendour!

One after one, as I took up and handled these radiant jewels,

and admired their beauty, I have sought anxiously and prayerfully, that I might be directed to restore it to that precise part from whence, in the lapse of ages, it had fallen; and as each gem assumed its place, and commingling in radiance, reflected a lustre on every other, and together displayed the full symmetry and beauty of the crown on which they were thus inwrought, I have at length been made to exclaim—Behold how glorious! How worthy of the great Creator, who by His wondrous wisdom and His power framed and fashioned them all at first!

Before I proceed, however, to the development of my cosmographical conceptions, or enter upon the intricacies of argument, it may be conducive to give a summary of those principles of belief which will be found at the bottom of them all; and which, indeed, alike constitute their ground-work, and support their subsequent superstructure.

These are, in the first place, that the Bible contains a revelation from God: and that "a revelation" is a discovery by God to man of Himself—that is, of His attributes, His works, or His will, over and above what He has been pleased to make known by the light of nature or reason.

That, as no material thing is self-created, all must possess a condition which has not emanated from materialism, and, therefore, to attain a perfect knowledge of whatever the senses make known to us, we must, after receiving all the answers which nature can give to our enquiries, apply to a source above and beyond it. *For nature cannot answer all the questions requisite to be put to it, in order to comprehend its objects thoroughly*, and having thus to apply to a source beyond nature, we must appeal to the Bible; *the only* revelation from God the Creator.

That the Bible can afford whatever explanation is wanting by the light of reason for a perfect comprehension of the works of creation; that in it nothing is overlooked, nor is there in it anything redundant; and that the words of the *first* chapter of Genesis detail, in the only way in which man can be made to comprehend it, the unfolding of the plan of creation, devised from all eternity; that these words embody NATURE'S CONSTITUTIONAL CODE, which it cannot fail implicitly to obey; and, therefore, to understand it thoroughly we must become acquainted with *them*. That whatever is mentioned in the first chapter of Genesis as having been either created, made, suspended, or changed by God, has from thenceforth become a primary, permanent cause, with no intervening cause between it and the Creator; and, therefore, all attempts to investigate the *unrelated* or *intimate* nature or composition of such, must, as a matter of course, prove entirely fruitless. That we can know only what is revealed respecting it, and acquire an intimacy with its *relative* nature in respect to other material substances around.

That all results not directly mentioned in the first chapter of

Genesis, but which are implied, are *secondary causes*, emanating themselves from primary causes, and together producing those effects which, from their persistency, are termed *natural*. And that all alike—of whatever description—originated from God the Father, God the Son, and God the Holy Spirit, "without whom was not anything made that is made."

That previous to the Mosaic week, and during the protracted period called the beginning, God created certain substances, organic and inorganic, whose existence (although they are not particularly described) is assumed, and clearly inferred by the inspired historian in his subsequent narrative. And, further, that during the six working days of the Mosaic week, each day consisting of twenty-four natural hours, these primary substances were wrought up, transformed, or modified by the Creator into the varied objects which now compose the material universe.

That while unfolding the numerous conceptions which have conspired to produce the most prominent dogma of this theory, *the non-rotation of the Earth around its axis*, I finally believe, that scientific research has attained a state of perfection sufficient to enable us, by judiciously blending its truths with those of revelation, to produce such a system of cosmogony as shall meet all the requirements and fully satisfy the human mind, by convincing the understanding while it invigorates our faith in the Word of God.

To accomplish this I have, for many years, dedicated such portions of my time and attention as could with propriety be abstracted from more ordinary labours, and such as are usually given up to recreation. I have striven, by all means in my power, to infuse into this volume every particle of knowledge which I either possess or can by possibility acquire. In fine, I have done what I could for the cause of truth, sacred and secular. With a willing heart and a sincere intention I have laid the results of my labours at the feet of the Creator, and upon the altar of His word; and while lamenting that I have not had it in my power to present a more perfect or acceptable offering, I feel assured that what I do present will neither be rejected, nor will my hope be lost. And I have, therefore, now merely to desire, that we each may be blessed in the execution of our respective duties: I, in endeavouring to make plain what I have to say; the reader, in his endeavours to comprehend, to advantage, what is to be laid before him.

The quotations from Scripture and the Theorems which are given in the Appendix, are intended to constitute the groundwork of my subsequent reasoning, and may therefore be referred to when necessary. On the one hand, I have in them given, from the Record of our Faith, the enunciations of the Spirit of Truth relative to a period when there was no created being to bear witness to what was done: "Where wast thou when I laid the foundations of the earth? declare if thou hast understanding!" And, on the other, I have se-

lected, from the writings of the learned and the laborious in research full and complete evidence of that which exists and is appreciable by the senses. The one reveals to us how all things were formed; the other displays the state in which they are found after having come from the hands of the Creator. Assisted by both, I shall endeavour to thread my way through the various branches of argument designed to bring out, in clear and consistent manifestation, the beauteous system of belief which these infallible sources of information and evidence, when taken together, are capable of affording to the mind of man.

But, before I proceed any further, and while yet on the threshold, I take occasion to observe, that unless my readers are prepared to receive the announcements of Scripture with as implicit confidence as they would a thrice demonstrated problem, it will avail them little to accompany me. We shall be losing sight of each other at almost every turning and winding of the long and intricate path which lies before us: for, I consider it an axiom that there is only one reliable source of information *respecting that which was, and of events which occurred immediately preceding the present order of things;* especially as the preceding did not stand in the relation of natural *cause* to the succeeding, as its *effect;* but indispensably required, in order that it might become so, *intervening acts of Omnipotent will and power.*

Before commencing my discourse, I have to make a few observations, as to the method which I propose to adopt in conducting these investigations.

To avoid unnecessary repetition, and to render the work as concise as possible, I shall give only a limited number of authorities in support of those points which it may be deemed necessary to establish; for, where unanimity prevails, further evidence would render the a discussion diffuse, and distract the attention: where it does not, multiplicity of quotations would only increase the difficulty. In making the selection, I shall be guided alone by expediency; preferring, in general, those quotations which most clearly and concisely describe the subject to be established, and which afford the best evidences in its favour. In order to convince the understanding it may, in some cases, perhaps, be requisite to bring forward proofs in support of points which might be assumed by common consent. But to compensate for this, I shall endeavour to restrict my own observations to such as may be necessary to bind one link of the argumentative chain to another; and the whole, I trust, to the minds of my readers.

Some difficulty exists in making a proper selection of the first link to be examined, for the whole is bound together in a circle, the one dependant on the other; no point presenting itself in well marked and visible separation so that it might be laid hold of, and enable us, link by link, in continuous succession, to unravel the whole. I

have, however, after mature reflection, adopted the only plan which bids fair to obviate this difficulty, namely:—to commence at whatever part of the argument appears to be most conducive to its eventual success, and *interim, assume as established* whatever other conditions may be necessary for the perfect support of that which first occupies my attention, and, afterwards, to return upon those which have been thus assumed, and prove them also, on the precise understanding, that should I fail to establish whatever may have been made use of provisionally, then the superstructure will fall to the ground along with that on which it was erected. The point with which I have chosen to commence has likewise this recommendation, that it is the most analogous to that where the narrative commences in Scripture: a motive which I trust will also have due weight with the reader.

SECTION I.

THE ANIMAL EXISTENCES OF THE NON-ROTATORY PERIOD.

CHAPTER I.

Subject of Argument in the present Section. Early conception of a Principle of Limitation involved in the Mosaic Record. "The Moving Thing that hath Life." Definition of the Living Principle. Faint Line of Separation between Vegetable and Animal Vitality. Difference determined; and also that between Vertebrate and Invertebrate Animals. The former accurately defined and described for the purpose of being eliminated from the argument. The same method adopted with respect to certain Mollusca, Articulata, and Radiata. Apulmonic Tribes of Animals defined generally. Described particularly and very fully, and confirmed by general testimony. Nature and Habits of the Extinct Races of Inferior Animals. Evidence of the Extinction of their Races, and of the successive Creation of others. The Design and Object of the Temporary Existence of the Inferior Apulmonic Animals, with a view to resume, and dwell, in the sequel, upon both of these points.

In conformity with the resolution thus adopted, I shall, for the present, consider the Earth *as a sphere, surrounded by an atmosphereless ocean of different composition from the actual seas, and, under the influence of the same forces which at present govern its orbital motion, revolving in darkness round an unillumined sun, but without rotatory motion.* And having done so, I shall endeavour to prove, as my first position, *that these primitive, dark, and atmosphereless waters were the abode of innumerable races of living apulmonic creatures, independent alike of light or atmospheric air for life or motion; the greater part consisting of descriptions which either were entirely fixed or moved but imperfectly. That of these there were several successive generations. And that the assumptions are as consistent with the true meaning of Scripture as they are accordant with the results of philosophical investigation and of geological research.*

It may, perhaps, be attended with beneficial effects, were I to trace the outlines of the path by which I became convinced that the Earth had revolved for ages in a state of non-rotatory motion around the unillumined sun; that it had been the abode of certain classes of molluscous animals, whose shelly coverings are everywhere discoverable in its stratified masses; and that all this had been *previous* to the Mosaic week. Long after I arrived at that conclusion, I was under the most painful perplexity as to how such a state of matters could be made reconcilable with the announcements of Scripture; prepared, as I was, to give up everything which might be at variance

with this standard of my faith: believing, at the time, most firmly, as probably all do who have not paid the like attention to these points, while they possess equal confidence in the word of God, that no warrant was to be found in it for the conclusion that *anything could possibly have existed which was not made during the Mosaic week.* The consequent state of mind was, of course, far from enviable. It was positively distressing, for, relying most implicitly on the words of the Divine Record, and ready to sacrifice every thought which might be inimical to it, I could not, on the other hand, close my eyes to the full glare of noon-day light, to the conviction of my senses, which led me to conclude, by what I saw around me, that the remains of those marine animals, found everywhere on the face of the earth, and high above the present level of the ocean, must have been deposited previous to the revolution of the globe around its axis; consequently, before the formation of the light, and while as yet the primeval ocean surrounded its entire spherical surface.

Assailed thus powerfully and equally by contending opinions, both of which bore the evidence of conviction, while they seemed to resist a cordial reconciliation with each other, I was completely at a loss which way to turn. During one of these fierce and protracted contests, when every argument had been tried, and every *instantia crucis* had been brought forward in vain; when, almost worn out with the intensity and tenacity of the jarring principles within, and about to seek rest by abandoning the philosophical evidences altogether and adhering implicitly to the words of inspiration, it occurred to me, as a last resource, that, perhaps, the expressions therein made use of might admit of such an interpretation as would pave the way to a thorough reconciliation between the two branches of evidence; and thus might be avoided the sacrifice which I felt inclined to make, to secure, as I then thought, the tranquil enjoyment of my scriptural tenets, but which, in fact, would have had the effect of greatly lessening that enjoyment.

Fortunately, the Bible, which at that juncture lay most convenient for immediate consultation, was the celebrated Spanish one by the very Rev. F. Scio de San Miguel; on taking it up and referring to the passage in question, I found the following explanation, which, unphilosophical as it may appear, supplied the first step towards unravelling the difficulty:—

"God also said, Let the waters produce animated reptiles* (more lite-

* That is, animated *reptiles*, or those which have life. Fishes are so called, because what is principally recognized in them is the head and tail; and as they are deficient of limbs (literally of both *legs and arms*), they appear to move as if dragging themselves through the water. And thus the word "*reptile*" is alike applicable to fishes which swim and to animals which drag themselves along the ground.*

* "Dixo tambien Dios; produzcan las aguas reptil,* de anima viviente, y ave que vuele sobre latierra debaxo del firmamento del cielo."

* "Esto es, Reptiles animados, o que tengen vida, asi llaman a los peces, porque lo que principalmente se reconoce en ellos, es la cabeza y-la cola; y-como carecen de pies y de brazos, parece que van arrastrandro por las aguas. Y, asi el *Reptil* se aplica tanto al pez que nada, como al animal que va rastrando por la tierra."—*Biblia por el M. R. P. Phelipe Scio de San Miguel. Tomo* 1, *pagina* 8.

rally, "reptiles of living minds"), and birds which fly above the earth under the firmament of heaven. Gen. i. 20.

This, although a very unscientific explanation of the passage commented on, nevertheless was made the means of awakening me to a conception of the truth, faint, it must be confessed, at first, but sufficient, notwithstanding, to mark where the point of junction lay between two masses of undeniable evidences.

On turning from the Spanish theologian's explanation to that given in our own version, I was struck with the apparent analogy, and at the same time with the seeming care which had been employed in framing that part of Scripture. The words "*moving creature that hath life*" kept possession of my mind with the tenacity of that which is destined to take root and flourish—with the glow of vitality itself.

But, as already indicated, the imperfect explanation afforded by the Spanish translation, led only to the first step of my enquiry into the real facts of the case. It directed my attention, with undeviating steadiness, to the *principle*, which induced the peculiar wording of this portion of Scripture—and that *principle* was, *that a line of division had been intended to be clearly and emphatically drawn between certain races of marine creatures which were, by the Command itself, to start into being, and certain other tribes of the same grand division of animal life, which had existed previously.*

Convinced of this, my next step was to ascertain, if practicable, the direction of this line of demarcation, or the point where it commenced on the scale of creation. After much thought it occurred to me, that if the *revealed* were perfectly known and applied to the *whole existing races* of animated creatures, all those which are over, as it were, must have been willed previously into being. For the *revealed might* be known, but the *un*revealed could only thus be inferred, and afterwards be confirmed by a comparison with fossil exuviæ. Subsequent enquiries into the more precise meaning of the words used, at the commencement respectively of the 20th and 21st verses, convinced me that when applied to the collective tribes of creatures known to inhabit the waters, they seemed to exclude a vast multitude. They could not, I imagined, comprehend those which are fixed to other bodies; those which creep along the bottom of the ocean; nor any which do not possess the faculty of moving freely and rapidly. In short, all that are independent of atmospheric air to sustain them in life and to enable them to move. Every creature so constituted, whatever may be their form or constitution, I therefore apprehend, was known by the inspired historian to have existed previously, and, therefore, *had been carefully and deliberately excluded from the Creative Command on the fifth day of the Mosaic week.*

From the moment I came to this conclusion I never doubted but the principle which led me to it would afford me the long-wished-for explanation of this hitherto inscrutable arcana; and my

attention, thus freed from doubt, became wholly directed to ascertain whether the discoveries of philosophy would bear out these robust, but incipient conceptions. I proceeded by the way of differential reasoning, if I may be permitted so to express myself, and the more I read, studied, examined, and compared, the more firmly I became convinced that I was on the right path. That those marine animals *which do not* depend for motion on atmospheric air were capable of existing previous to the formation of the light; that *they* only could fulfil the purposes which were then to be wrought out; and, knowing this, the inspired historian meant, as I have said, carefully and deliberately to exclude them from the narration given of the operations of the *first part of the fifth day.* The result of these researches, in further confirmation of my assumption, I now proceed to lay before my readers.

I shall commence by enquiring, whether naturalists acknowledge a class or division of beings corresponding to the definition I have just given; observing, in general, that whatever creatures did exist *before* the formation of the atmosphere *must have been inhabitants of the water.*

Let us first, then, examine the evidences in favour of what it is to be possessed of life, or of the *living principle.* By the first part of the *hundred and twenty-ninth* Theorem it will be seen "*That the want of organization is the peculiar characteristic of mere inert matter; affords an evidence of the absence of the living principle; and proves that it never has been present in these bodies during their formation or increase, while the slightest trace of organization discoverable in any natural body is a complete proof that life is, or at least once was, present in it.*"* These are the words of Professor Henslow, in his Treatise on Botany in the Cabinet Cyclopædia. We shall see, presently, how fully his proposition is borne out by the opinions of other writers.

"Life," says Baron Cuvier, "being the most important of all the properties of created existence, stands first in the scale of characters. It has always been considered the most general principle of division; and, by universal consent, natural objects have been arranged into two immense divisions, ORGANIC beings (comprising animals and plants); and INORGANIC beings (comprising minerals)."

And again,

"In conclusion, we shall repeat, that all living bodies are endowed with the functions of absorption (by which they draw in foreign substances); of assimilation (by which they convert them into organized matter); of exhalation (by which they surrender their superfluous materials); of development (by which their parts increase in size and density); and of generation (by which they continue the form of their species). Birth and death are universal limits to their existence: the essential character of their structure consists in a cellular tissue or network capable of contractibility; containing in its meshes fluids or gases, ever in motion; and the bases of their chemical

* See Appendix, for the Theorem itself.

composition are substances easily convertible into liquids or gases; or into proximate principles, having great affinity for each other. Fixed forms, transmitted by generation, distinguish their species, determine the arrangement of the secondary functions assigned to each, and point out the part they are destined to perform on the great stage of the universe. These organised forms can neither produce themselves nor change their characters. Life is never found separated from organization; and, whenever the vital spark bursts into a flame, its progress is attended by a beautifully organized body."*

"It is very difficult," say Messrs. Tod and Bowman, in their admirable Physiological Treatise, "to define a precise boundary between the vegetable and animal kingdoms. The lowest animals exhibit so much of the plant nature that naturalists are as yet undecided as to the true location of some species. The common sponge, for instance, is claimed for each kingdom. Yet *living* objects, generally, are strongly contrasted with the inanimate bodies (which have never lived).

"The term LIFE, indeed, may be regarded as denoting an ultimate fact in science, which may be thus expressed: that certain compounds of matter —which, as being artfully arranged in a particular form for a special end, and associated together by a certain mechanism, are called *organized*—do, by their co-operation with physical and chemical forces, manifest a train of phenomena, which are of the same, or of an analogous kind, for all organized beings; that is to say, they manifest the phenomena of LIFE. . . . . Life is transmitted from one living being to another; the life of the present generation of animals and plants has its source in that of a previous generation.

"And if we trace a race upwards through generations innumerable to that which first flourished on the earth, we find the true source of vital creation to be in Him 'in whom we live, and move, and have our being.'"†

Having ascertained, from these authorities, what the characteristics are which constitute an organized or living being, it becomes necessary to delineate, as clearly as possible, the distinguishing properties of the animal from the vegetable kingdom.

By the *one hundred and twenty-ninth* Theorem it will be perceived that the lower boundaries of these two divisions of organized existences are so contiguous, indeed so frequently blended, that it "*has hitherto baffled the attempts of naturalists to point out the precise limits which separate them;*" for, to this day, there are some objects which it is very doubtful under which class they ought to be arranged. Observe what Professor Henslow says in continuation of these words which I have selected for the Theorem:—

"Among the higher tribes of organized bodies, indeed, there is no difficulty in pointing out numerous lines of demarcation between the two kingdoms; but, as we descend in the scale of each, we find an increasing similarity in external characters, and a closer approximation between the analogies existing in many of those functions which mark the presence of the living principle, both in the animal and in the vegetable kingdoms.

* Edinburgh Philos. Journal.

† Physiology and Anatomy of Man. London, 1845, pp. 21, 22, 15.

"Indeed, so very closely do the limits of these two great kingdoms approximate, that it is even now a matter of doubt whether the *Conferva Comoides*, which has hitherto been considered as an aquatic plant, does not more properly pertain to the lower confines of the animal kingdom. An opinion which has been adduced from observation by Mons. Gaillon, and confirmed by the later investigations of MM. Desmazieres and Chauvin."

But difficult as it may be to effect this separation, an attempt has been made to accomplish it; and with relation to the *hundred and thirtieth* Theorem it may be observed, that the following seem to be the conditions which essentially constitute the animal state of organic existence; those which do not possess these qualifications taking their rank in the vegetable kingdom:—"1. *Animals are possessed, in some form or other, of an alimentary cavity, or intestinal canal.* 2. *They are endowed with a circulating system.* 3. *That, besides the three elements, oxygen, hydrogen, and carbon, which both plants and animals contain, the latter have a fourth, namely, azote, or nitrogen, which enters more largely into their composition.* 4. *They possess the power of respiration. And lastly. That, perhaps, the super-addition of sensibility to the common living principle, is requisite to complete the characteristic property of animals.*"

Baron Cuvier, in the introduction to his "Animal Kingdom," confirms these positions by stating

"The power of voluntary motion in animals necessarily requires corresponding adaptations, even in those organs simply negative. Animals cannot, like plants, derive nourishment from the earth by roots; and hence, they must contain within themselves a supply of aliment, and carry the reservoir with them. From this circumstance is derived the first trait in the character of animals. They must possess an intestinal canal, from which the nutritive fluid may penetrate by a species of internal roots, through pores and vessels into all parts of the body. . . . .

"The complicated functions of animals require organized systems, which would be superfluous in vegetables; such as the muscular system for motion, and the nerves for sensation. It was also necessary that the fluids should be more numerous and varied in animals, and possessed of a more complicated chemical composition than in plants, in order to facilitate the action of these two systematic arrangements. Therefore another essential element was introduced into the composition of animals, of which plants, excepting some few tribes, are generally deprived; and while plants usually contain only three elements, oxygen, hydrogen, and carbon, animals add to these a fourth, namely, azote, or nitrogen. This difference in chemical composition forms the third trait in the character of animals.

"Respiration forms the fourth characteristic of animals, and is the most distinguishing function of the animal frame, namely, that which forms its essential difference from all other beings, and, in a manner, constitutes it an animal. So important is its influence over the whole body, that we shall presently be able to show that animals perform the functions of their nature with greater or less perfection, according as their respiration is more or less perfect."

We can now distinguish an organized being from mere inert

matter which constitutes the mineral kingdom; and have acquired such a knowledge of the characteristic peculiarities of an animal, as to distinguish it from a plant. In short, we now know *what a "creature"* is which *hath "animal life."* In continuation, I shall enquire, whether any of these are so circumstanced as to be independent of light and atmospheric air; commencing with such as, being immovable during the whole period of their existence, are most decidedly indifferent to both these influences. In effecting this, I wish it to be clearly understood, that the *immovability* to which I allude is that which is akin to the *immovability of a tree;* whose static condition cannot be questioned, although its seeds may be wafted by the winds, or borne by the waters to a distance, there to take root, and, in turn, from thence to spread further and further over the face of the earth. In like manner, I assert, that any mollusc or zoophite which ultimately adheres to a rock, and thereafter continues fixed, is *an immovable creature*, although it should be proved that its spawn separates itself from the parent mollusc; and and, either by the currents of the water, or even by rotiferous motion, succeeds in reaching a convenient distance from the original bed; there, like the race to which it belongs, to become a permanent fixture, and to send forth, in turn, animals of its own kind, ephemerally endowed with the faculty of locomotion. I maintain, therefore, that, in respect of fixity, these two extensive groups of created existences are precisely upon a par, and that the immovability of the *ostrea* or the *patella* can no more be questioned than that of a shrub or a tree. While by "restricted motion" I mean such as, during the whole course of their existence, creep upon, or burrough in the bottom of the ocean, and are incapable of swimming freely. In short, all those whose motion is not the effect of aerated blood, even although they should, by means of the surrounding element, be capable of restricted movements of mechanical origin.

In conducting the inquiry into this matter, I shall eliminate those animals whose nature and conformation leave no doubt as to their possessing the power of locomotion, close in by degrees upon the more questionable descriptions, situated upon the very line of demarcation, and, passing on, at last arrive at such as are positively deprived of the faculty in question.

By the *hundred and thirtieth* Theorem it is asserted "*That the animal kingdom, from the most perfect of its beings down to the verge of that indistinct line where it comes into contact with the vegetable kingdom, may be comprised within two grand divisions, namely,* VERTEBRATE *and* INVERTEBRATE. *The former provided with a skull and vertebral column for the protection of the brain and spinal marrow. The latter being destitute of both of these defences.*"

This is so rudimentary a truth in natural history, and so well known to all who have paid the slightest attention to its study, since Lamark adopted this method of classification upon *positive* and *nega-*

tive principles, that it is scarcely necessary to delay the investigations to prove it. I shall, therefore, proceed to give the description of animals which constitute its *positive branch*—the VERTEBRATE:—

"VERTEBRATED ANIMALS," says Baron Cuvier, "the first of whose forms is that of man, and of the animals most resembling him, have the brain and the principal trunk of the nervous system enveloped in a bony covering, composed of the cranium (or skull), and the vertebræ (or bones of the neck, back, and loins). To the sides of this medial column are attached the ribs, and the bones of the limbs, forming collectively the framework of the body. The muscles, in general, enclose the bones which they set in motion, and the viscera are contained within the head and trunk. They are all supplied with red blood, a muscular heart, a mouth with two jaws, one being placed either above or before the other, distinct organs of sight, hearing, smell, and taste, in the cavities of the face, and never more than four limbs. The sexes are always separate, and the general distribution of the medullary masses with the principal branches of the nervous system, are nearly the same in all. Upon examining attentively each of the parts of this extensive division of animals, we shall always discover some analogy among them, even in species apparently the most removed from each other; and the leading features of one uniform plan may be traced from man to the lowest of the fishes."*

No further evidence need be adduced on this point: whoever reflects for a moment must be convinced, that the very possession of a skull and vertebral column, with their contents and accompaniments, the brain and spinal nervous cord, is sufficient proof that their possessors *live and move themselves.* But that we may know which animals belong to this class, the list is subjoined which is given of them by the same illustrious anatomist:—

THE ANIMAL KINGDOM.

DIVISION I.—VERTEBRATA.—Subdivided into four Classes.

1. MAMMALIA.—Man and beasts with warm blood; heart with two ventricles; females suckling their young with milk; viviparous, excepting the Montremata, which are either viviparous or ovoviparous.
2. AVES.—Birds, with warm blood; heart with two ventricles: no mammæ; oviparous; body covered with feathers; and organised for flight.
3. REPTILIA.—Reptiles, with cold blood; heart with one ventricle; having lungs, or sometimes only gills or branchiæ; oviparous or ovoviparous, generally amphibious.
4. PISCES.—Fishes, with cold blood; heart with one ventricle; no lungs, but breathing by branchiæ; generally oviparous; *body organized for swimming.*

Without hesitation, I eliminate from the future argument, the whole of the multitudinous tribes of animals which comprise these

* In the Appendix there will be found a Synoptical Table of the entire animal kingdom, according to Baron Cuvier, to which please refer.

four classes, MAMMALIA, AVES, REPTILIA, and PISCES. They were all called into existence on the fifth and sixth days of the Mosaic week. Not one of them existed previously.*

Of the other three divisions, MOLLUSCA, ARTICULATA, and RADIATA, *some* of the classes are as decidedly on the same side of the line of demarcation; and I proceed to single them out, that they also may be set apart. They are

DIVISION II.—MOLLUSCA.—Subdivided into six Classes.

1. CEPHALOPODA.—Cuttle fishes, having the mantle furnished with a shell, and united under the body, forming a muscular sac; head connected with the mouth of the sac, and crowned with long and strong fleshy limbs for swimming with and seizing their prey; two large eyes; and two gills placed in a sac; sexes separate.
2. PTEROPODA.—Marine animals without feet; with two fins, placed one on each side of the mouth; head distinct; hermaphrodites.

DIVISION III.—ARTICULATA.—Subdivided into four Classes.

2. CRUSTACEA.—Marine animals, with a crustaceous envelope; having articulated limbs attached to the sides of the body; blood white; always with articulated antennæ or feelers in front of the head, and generally four in number; distinct organs of circulation; respiring through branchiæ.
3. ARACHNIDES.—Spiders, with the head and breast united in a single piece; and with the principal viscera situated in a distinct abdomen behind the thorax; without antennæ; oviparous.
4. INSECTA.—Insects divided into three distinct parts, the head, thorax, and abdomen; always with two antennæ, and six feet.

DIVISION IV.—RADIATA.—Subdivided into five Classes.

2. ENTOZOA.—Intestinal worms, with no distinct organs of circulation or respiration; body generally elongated and organs arranged longitudinally, without head, eyes, or feet.
3. ACALEPHÆ.—Medusa, or sea nettles, without organs for circulation or respiration; with only one entrance to the stomach.
5. INFUSORIA.—Animalcules, or minute microscopic animals, found in fluids, or vegetable infusions. As their internal structure is but little known, from their extreme smallness, this class will probably be found, hereafter, to contain animals which ought to be placed in some of the higher divisions.

These eight classes, CEPHALOPODA, PTEROPODA, CRUSTACEA, ARACHNIDES, INSECTA, ENTOZOA, ACALEPHÆ, and INFUSORIA, may also, I think, without any fear of regret hereafter, be eliminated at once, as pertaining to "*the moving creature that hath life;*" and, for the

* In making this assertion I am well aware of the difficulty which may arise respecting the *fourth* great class, PISCES; but, besides having reference to *true fishes* only, or such as are possessed of perfect organs of locomotion, I am prepared to explain, in the sequel, the peculiar difficulties which beset this part of my discourse. Meanwhile, I shall proceed on the assumption that no *true fishes* which aeriated their blood by gills or branchiæ did exist during the preparatory stage of the world, or *before* the Mosaic week.—AUTHOR.

same reason, will not again require to be referred to, or brought forward.

It is extremely difficult, when treating of a description of animals whose habits are so little known as those of the inferior tribes of MOLLUSCS, RADIATA, and ZOOPHYTA, to be able to draw a line of separation between those endowed with the faculty of locomotion and those which are deprived of it: a difficulty by no means lessened by having to infer the habits of extinct races by comparison with living congenors. We must, however, endeavour to assign limitations sufficiently plain to render ourselves independent of very minute lines of distinction. If a creature be dependent for life and motion on atmospheric air it is on the one side: if it be not, it is on the other. Nevertheless, to enumerate all that are on either side of that great boundary line would lead to details too diffuse and inconsistent with the design of this work. I shall, therefore, to avoid those, adduce the distinguishing characteristics of entire groups, which sufficiently evidence the immovability of numerous included tribes of submerged aquatic animals. The following, which is Baron Cuvier's classification, is the most appropriate for my purpose:—

DIVISION II.—MOLLUSCA.

4. ACEPHALA.—Aquatic animals, generally with a bivalve or multivalve shell; without any apparent head or limbs; mouth concealed between the folds or in the bottom of the mantle; hermaphrodites; bronchiæ external; *incapable of locomotion.*
5. BRACHIOPODA.—Marine animals, without a head; having two fleshy arms, furnished with numerous filaments; bivalve shells, *incapable of locomotion.*
6. CIRRHOPODA.—Barnacles, enclosed in a multivalve shell, with numerous articulated limbs or cirri, disposed in pairs, *incapable of locomotion.* General structure approaching to articulated animals.

DIVISION IV.—RADIATA.

4. POLYPI.—Small gelatinous animals, with only one entrance to the stomach, surrounded with tentacula; generally adhering together and forming compound animals.

Probably, before I quit this branch of the general subject, I may have occasion to exhibit some further particulars respecting the animals comprising these classes, and to refer to them repeatedly during the whole treatise; but in the meantime it is considered to be deducible from the direct though unconscious testimony of a man, whose evidence it will be somewhat difficult to set aside, that the three first—ACEPHALA, BRACHIOPODA, and CIRRHOPODA—belong to the great division of "*immovable* creatures that hath life;" are independent of atmospheric air, and as such must rank accordingly in all deductions which may, hereafter, be legitimately drawn from that fact. It will also, I think, be readily conceded that the *Polypi*

—with some slight exceptions—which include the Zoophyta, may be added to those which find themselves also on the *immovable* side of the line of demarcation.

Of the Third Division, ARTICULATA, I have already allocated the *Second, Third,* and *Fourth* classes to the great group of animals fully possessing the *faculty of locomotion;* therefore, I have only now to account for the several *Orders* comprising the

1. CLASS.—ANNÆLIDES. Of this class, the several *orders* composed of molluscs, may be considered as having the power freely to change their position at will, being generally without shelly coverings, and consequently irrelevant to the present argument, except the

1. ORDER.—SEDENTARIÆ, consisting of the following four tribes and fourteen genera, all of which are protected by a testaceous tube which they never leave during life; and have the bronchiæ at one extremity of the body, namely:—

TRIBE I. SERPULACEA.—*Genus* 1. Megilus; 2. Galeolaria; 3. Vermilia; 4. Serpula; 5. Spirorbis.
" II. AMPHIHITÆA.—*Genus* 6. Amphihita; 7. Terebella; 8. Sybellaria; 9. Pectinaria.
" III. MALDONIÆ.—*Genus* 10. Dentalium; 11. Brochus; 12. Cornuoide; 13. Clymene.
" IV. DORSALIÆ.—*Genus* 14. Siliquaria.*

To these several tribes and genera I lay claim, as pertaining to the grand *Scriptural* division of animals *which live, but move not voluntarily and freely from place to place.*

This brings us to the two remaining classes of the Cuvierian arrangement of the Animal Kingdom, namely,

II. *Division (Cuvierian)* MOLLUSCA.
III. *Class.—Gasteropoda.*
IV. *Division.*—RADIATA.
V. *Class.—Echinodermata.*

and which, with the exception of the *Pulmonata,* will eventually be found to belong to that great group of *living creatures which do not move by means of aerated blood.*

The general classification I have thus given seems to embrace the animals which, with great deference, I consider to be distinctively characterized as those which may not be considered "*the moving creature that hath life,*" and known as such to the inspired writer of Genesis to have existed in the primeval ocean, unendowed with the faculty, in its plenary sense, of self-movement; in a condition somewhat analogous to that of the globe they inhabited, which was without rotatory motion, uncheered by the light of the sun, and as yet without an atmosphere.

* Conchologist's Text Book, pp. 148, 159.

That we may be better able to apply these results to future reasoning, by identifying those tribes which are considered to have belonged to the non-rotatory period with the lists of fossil exuviæ brought to light by geologists, there will be found in the Appendix a more detailed list of those which I consider to have belonged to the *primitive* division.*

I have thus endeavoured to trace the line of separation between "the moving creature that hath life," and the Testaceous, Molluscous, and Zoophytic inhabitants of the ocean which are endowed with life, but not with the faculty of free and rapid locomotion, with as much distinctness as the state of information on that particular description of animal life will permit.

In conducting this investigation I have necessarily been actuated by the different relations of the subject towards the existences which are ranged on the opposite sides of that principal boundary line. "The moving creature that hath life" (more easily characterised by the possession of organs indicative of motion), not being essential to prove any future assumptions, I have, at once, discarded them from the attention and the memory; while, on the other hand, I have sought, by a recapitulation of the various Classes, Orders, Tribes, and Genera—deduced from the most elaborate classifications of modern Conchologists—to arrest the attention, while I impressed the memory with particulars respecting those creatures actually ascertained to be, or which are considered to be on that side of the line which implies that either entire *immovability* or *restricted motion* is their lot; an additional labour undertaken, not only with the design of more effectually separating those two divisons, but in order that, when we come to compare the description of animals which are considered to be of primitive origin, with the fossil remains brought to light by geologists, we may be enabled to arrive at more satisfactory and more correct conclusions.

The following corroborating testimonies, although couched in general terms, are deserving of attention, considering the assiduity and the success of the researches made by their authors into this particular branch of natural history:—

"Besides possessing the faculty of sensation and voluntary motion," says Dr. Fleming, "I likewise am able to move my limbs in such a manner as to change the position, not of one organ merely, but of my whole body, or to shift from one place to another. This new action is termed *Locomotion*. It requires for its performance, not merely the conditions requisite for sensation and voluntary motion, but likewise an arrangement of organs so constructed as by their action on the surrounding elements, whether of air, earth, or water, the body may be displaced. Quadrupeds, birds, reptiles, and fishes, possess such an arrangement of organs, and exhibit the locomotive power in a great degree of perfection. But as we descend in the scale, we find many animals in which such an organization does not exist, and

* See Appendix B.

that live on the same spot from the commencement to the termination of their existence.

"Those animals, however, are all *natives of water*, and although they be thus stationary themselves, the fluctuations of the element in which they live produce a variety in the scene, and daily bring new objects in contact with their organs of sensation.

"Among the invertebral animals, in which the faculty of locomotion is not present in every species, there does not appear to be any link in the chain, or any system of organs connected with other functions, which regulate the presence or absence of locomotion. The *Monas*, usually considered as the lowest term of animal life, and in which neither mouth nor vessels can be perceived, is an animalcule which resides in water, and performs all its locomotive evolutions with considerable rapidity. The *Oyster*, on the other hand, in which a heart, bloodvessels, brain, gills, and stomach, may be easily observed, has one valve of its shell cemented to the rock, and depends on the bounty of the waves for all the objects of its sensation and nourishment. . . . .

"The fourth method," continues Dr. Fleming, "termed *Cementation*, employed by animals to preserve themselves stationary, consists in a part of their own bodies being cemented to the substance on which they rest. This takes place in the common mussel, by means of strong cartilaginous filaments, termed the *byssus*, united in the body to a secreting gland, furnished with powerful muscles, and, at the other extremity, glued to the rock or other body to which it connects itself. In other cases, as in the oyster, the shell itself is cemented to the rock. This method of resisting the action of the disturbing forces of the air and the water is unknown among the vertebral animals. In the Mollusca it occurs in those with shells termed *byssiferous* and *fixed*. . . . . Among the Zoophytes, the adhesion between them and the substance on which they grow is generally accomplished by means of a cement, connecting (as in nearly all animals fixed by cementation) their bodies for life to the spot where they first adhered."*

"The first thing that strikes a geological naturalist," observes Mr. Ansted, "in looking over the numerous fossils from the silurian rocks is the apparent want of fishes, and, indeed, of all vertebrated animals. Abundant proof is afforded that these were formed at the bottom of water: some in shallow parts, others in the deepest recesses of the ocean, but nowhere throughout their wide spread extent in all parts of the world, have they yet yielded the smallest fragment that could be referred to a fish. It is, therefore, pretty clear, either that fishes had not been created, or that the conditions for their development were so unfavourable that they were extremely rare. . . . . Until the termination of the first great epoch, the silurian, there seem indeed only to have been introduced successive modifications and additional species of the *Invertebrated* type, and not until its close did the fishes appear, as if preparing the way for the next period marked by the prevalence of these more highly organised beings. . . . . It is important to remember, however, that almost all the great natural divisions of the Invertebrata began at once and together to perform their work on earth. . . . . There is no appearance of any regular order of succession. . . . . . They seem

* Philosophy of Zoology, by Dr. Fleming, &c., vol. i. pp. 46, 47, 129, and 130.

to have been truly contemporaneous, and doubtless were introduced as the group best fitted to perform the functions of their existence."*

And the remaining extract is from the address of Sir R. J. Murchison, the President, at the opening of the British Scientific Association, at Southampton:—

"When our associate, Conybeare, reported to us at our second meeting, on the actual state and ulterior prospects of what he well termed the 'archæology of the globe,' he dwelt with justice on the numerous researches in different countries which had clearly established the history of a descent as it were into the bowels of the earth—which led us, in a word, downwards through those newer deposits that connect high antiquity with our own period, into those strata which support our great British coal-fields. Beyond this, however, the perspective was dark and doubtful—

Res altâ terrâ et caligine mersas.

Now, however, we have dispersed this gloom; and, by researches, first carried out to a distinct classification in the British Isles, and thence extended to Russia and America, geologists have shown that the records of succession, as indicated by the entombment of fossil animals, are as well developed in these very ancient or palæozoic strata as in any of the overlying or more recently formed deposits. After toiling many years in this department of the science, in conjunction with Sedgwick, Lonsdale, De Verneuil, Keyserling, and others of my fellow-labourers, I have arrived at the conclusion, that we have reached the very genesis of animal life upon the globe, and that no further 'vestigia retrorsum' will be found, beneath the protozoic or lower silurian group, in the great inferior mass of which no vertebrated animal has yet been detected, amidst the countless profusion of the lower orders of marine animals entombed in it."

By the evidences connected with the *hundred and thirty-third* Theorem it will also be seen that several families of testaceous and zoophytic animals have, by their petrified remains, been discovered by geologists to have become extinct; not in one formation only, but in a succession of geological formations; not in one part alone of the surface of our planet, but in groups over its whole extent.

It may have occurred to some that I have been too elaborate in treating of facts so well authenticated as these are; but I have to remind them that the general position taken up of the *primitive animal life having been restricted to beings* which were indifferent to light and atmospheric air, and either incapable, or almost incapable, *of locomotion*, occupies so prominent a part in the groundwork of this theory, that it requires to be fully proved and well-secured.

In continuation and with more direct reference to the numerous families of testacea and zoophyta which have become extinct, I shall recapitulate the *hundred and thirty-fifth* Theorem, *that when the* AUTHOR OF NATURE *creates an animal or plant, all the possible circumstances in which its descendants are destined to live are foreseen, and a corresponding organization is conferred upon it to enable the species to*

* Ancient World, by Ansted, London, 1847, pp. 25, 47—51, 395, 396.

perpetuate itself as long as is consistent with His omniscient purposes, under all the circumstances to which it will inevitably be exposed.

From so self-evident a proposition it is presumed that no one will be disposed to dissent. The admission of power and disposition to create, must be allowed to involve the power and the will to have overruled all concomitant circumstances, as far as is consistent with the general plan of creation.

The conviction, however, of the truthfulness of those two bodies of evidences, derived from distinct sources, added to the particular character of that which has reference to the fact of the testacea and zoophyta having, by families and by epochs, become extinct, places us in rather a rigid dilemma. On the one hand, while the validity of their having become extinct cannot be doubted, on the other, we cannot abate in any manner our dependence on the power and the care of a superintending Providence. To unravel the difficulty and to reconcile these points, while, at the same time, I corroborate the assumption of the degrees of *immovability of the creatures which then encrusted the solid parts at the bottom of the primitive waters,* will constitute the chief design of what is now about to be brought forward.

To satisfactorily account for the extinction of so many tribes of mollusca and zoophyta at several epochs and over the surface of this planet, it will be necessary to adopt one of the two following inferences which alike presume the direct interference of the Deity, namely, either that they were entombed by a succession of vast and general revolutions of the earth's stratified surface, extending simultaneously over the whole circuit of the globe, which so completely extirpated several races of its living inhabitants, that not one escaped, whereby its species might have been perpetuated; or, that it was merely an act of providence in the development of the plan of creation which brought about their extinction, when they had performed the object of their being, namely, *the exhausting the waters of those peculiar elements on which they could alone subsist.*

The former of these assumptions involves very many improbabilities; is at variance with the conclusions derived from the facts established by geologists; and is inconsistent with other general and prevailing laws of materialism; besides which, it is wholly incompatible with the principles of this theory (as I shall have occasion to prove in the sequel), to suppose that any such general and overwhelming revolution, or even any partial disturbance of the stratified envelopes of our sphere, ever took place, until, by the introduction of Light into the material universe, the earth was caused to rotate around its axis, and to occasion one mighty revolution amongst all the masses, which, for ages previously, had been accumulating in tranquillity at the bottom of its dark and atmosphereless circumfluent waters; and which, consequently, took place at a period long subsequent to that in which the animated immov-

able beings now alluded to had ceased to live, and had been profoundly entombed beneath the successive depositions of strata which took place from the associated elements of the primitive ocean.

The rejection, therefore, of that alternative reduces us to the necessity of adopting the other; and while I fully accord with the sentiments expressed in the *hundred and thirty-fifth* Theorem, I feel assured, in the words of an eminent geologist, that "whatever the kind of animal life may have been which first appeared on the surface of our planet, we may be certain that it was consistent with the wisdom and the design which has always prevailed throughout nature, and that each creature was peculiarly adapted to that situation destined to be occupied by it."* At the same time, I am as fully convinced that several tribes and families of animals of the lower orders have become altogether extinct. Their solid remains discovered in the strata sufficiently attest the fact.

But it has already been shown in a former part of this chapter, "that the slightest trace of organization discoverable in any natural body, is a complete proof that life is, or at least once was, present in that body;" and that one of the necessary conditions of a living being is "that of generation, by which they continue the form of their species," and that "fixed forms, transmitted by generation, distinguish each species, determine the arrangement of the secondary functions assigned to each, and point out the part they are destined to perform on the great stage of the universe. That organized forms can neither spontaneously produce themselves nor change their character. Life is never found separated from organization; and whenever the vital spark bursts into a flame, its progress is attended by a beautifully organized body."†

Now, there is undeniable proof, by means of fossil remains, that organization, and consequently the living principle, once existed; and, if the living principle, then the necessary conditions of life; and if the necessary conditions of life, then the power, by generation, of transmitting the form of their species; and, if the form, then the arrangement of the secondary functions assigned to each, and the part they are destined to perform on the great stage of the universe.

Recurring, however, to what has been established by the unanimous conclusions of geologists and comparative anatomists, that, although endowed with all those requisites, numberless families of the lower class of animated beings *have ceased to exist*, are no longer found holding a place amongst the innumerable living forms which inhabit the surface of the earth, I ask, how can these evidences be applied so as to prove that the extinct races were indifferent to light and atmospheric air, and, consequently, were not possessed of the faculty of free locomotion?

* De la Beche's Manual of Geology, 2nd edition, p. 476.

† For a corroboration of this definition see Messrs. Todd and Bowman on the Physiology and Anatomy of Man, vol. i. p. 10, et seq.

It has been asserted on the authority of those who have dedicated their attention to the subject, "that there could be no organic change wrought in the animal by its own agency; that fixed forms transmitted by generation distinguish their species, and determine the arrangement of the secondary functions assigned to each." This, then, precludes the possibility of change in the conformation of animal form itself, and guards, at the same time, against the error of supposing that any transmutation took place from form to form. It also proves *that had the attendant circumstances remained unaltered, the existing animals must have continued to have lived, and to have transmitted their forms to their succeeding generations.* But they did not do so, therefore *there must have been a change,* and such a change in the surrounding medium, from whence they drew their subsistence, as to occasion their gradual decrease, and ultimately, to cause their utter extinction.

One of the fundamental principles of this theory is, that the introduction of animal life into the world during the non-rotatory period, was with the design of interposing animal vitality and secretion between the solid mineral masses and the liquid waters; to disturb the chemical equilibrium to which the primitive fluid was ever prone to revert; to abstract certain earthy and acidulous elements held by it in combination, as shall be more fully shown in the sequel of this treatise; and to transform these ingredients into animal bodies and testaceous and zoophytic coverings, the direct tendency of which *was to effect a change in the constituent elements of the primitive ocean.* It must also be observed that, owing to the peculiarity of the concomitant circumstances, the ocean could not be replenished with the materials which were thus being absorbed from it, which were taken away once for all and transformed at its base into other distinct substances, and thus they became fixed and stored up for the future designs of the provident Creator.

Any change once begun under the circumstances here alluded to, namely—a living active agency operating upon an unrenewable amount of mere material—could tend only to one result:—*an exhaustion of the material on which the animal subsisted; and consequent thereon, an extinction of the animal itself.*

Another fundamental principle of this theory is, that neither the successive stratiform beds of rock deposited at the bottom of the primitive ocean nor the ocean itself were in a state of readiness to be transformed into their present condition until immediately before the first rotation of the earth; consequently *a succession of distinct vegetable and animal forms would be indispensable to bring both to that degree of perfection.* As one race of the latter exhausted its peculiar food and became extinct, another race would be willed into existence to occupy its place and to continue the labour of assimilation, purification, and solidification. If any races were so constituted as to subsist on that which remained in the waters during the whole

protracted time from the beginning until the period of rotation (and it is known that many elements did so remain), these races would exist through all the vicissitudes which necessarily extirpated others of more restricted assimilation.

While with reference to the employment of animal and vegetable agency for the purpose of simultaneously preparing the ocean and the earth's mineral crust, I may observe, that during the period in question and in an element such as water, which admits of its associated ingredients—on their equilibrium being disturbed—so easily to obey the laws of gravity and to take a downward tendency, the bottom of the ocean was, of all others, the most suitable position for the colocation of the multitudinous artificers which it had pleased the Creator then to employ. It was also the most benign, for the lowest stratum of water would be that in which the last particle of sustenance would be found by them. To have conferred the power of their going elsewhere in quest of what could not have been found, would, on the other hand, have been inconsistent with our ideas of the Creator's goodness; while it would have been positively inimical to His future plans, as I shall hereafter abundantly make manifest.

When, in regular sequence, we come to treat of the fossil vegetable remains of the era to which I now allude, it will be shown that there was a succession, likewise, of distinct *families of plants*. That the epochs of their existence are clearly demonstrated by their fossil remains which are discovered in the strata. That by this undoubted test it is known that in many instances they grew coevally with the existence of certain molluscous and zoophytic animals, likewise now extinct. That the greater part being furnished with roots, *they must have been attached to the bottom*, consequently, were fixed during the whole period of *their* existence to the spot where they once took root. From all of which considerations I cannot imagine any reason why we should admit the fixity of the plants, and doubt or deny the degrees of immovability which are contended for in the other; and the more so, as the absence in the animals of the usual organs necessary for locomotion is as direct a corroboration, though *negatively* so, in their case, as the *positive* proof of roots is in the case of plants. *Fixity* is the general law governing the latter; hence the presence of organs adapted thereto is sufficient to complete the identity. *Motion*, on the other hand, is the general law of animal life; therefore the *absence* of organs fitted to effect this must be admitted as a proof, equally valid, of their incapacity to fulfil the requirements of *their* general law of being.

It has been asserted, "that all the fixed animals of the present day are inhabitants of the water, whose fluctuations bring food within their reach:"* and, although this is very different from maintaining what the direct line of our argument would demand,

* Dr. Fleming's British Animals.

that all animals which depend for food on the surrounding element *must, necessarily, be fixed.* Nevertheless, there is a sufficiency of presumptive proof scattered throughout the writings of geologists who have given the subject their earnest attention, to show that the extinct *molluscous* and *zoophytic* creatures which inhabited the profundity of the primeval waters, were either fixed, or had not the faculty—in its usual general acceptation—of locomotion.

For, even were we to relax our confidence in the wisdom and benignity of the Creator, and suppose that—having willed those primeval animal forms into existence, for the purpose of purifying the waters, draining them of certain ingredients, and locking up those otherwise noxious materials in a solid, insoluble form, at the bottom of the ocean; while they at the same time contributed layer by layer to the outer crust of the Earth—He endowed them with faculties of locomotion, not only to impede the accomplishment of His own plans of infinite wisdom, by rendering uncertain the accumulation of their remains in any given locality, but to admit of their going in search of what the waters (by animal action and secretion) had been incapable of supplying!—I repeat, that were we even capable of adopting so improper a view as this would infer, it would still be requisite to explain why, both in form and in the massiveness of their outward coverings, they were creatures apparently so ill-adapted for locomotion, unless what I am so anxious to establish be conceded, namely, that primeval animal life, which is known to have existed, was restricted to forms which were either altogether deprived of the power of locomotion, or endowed with it in a very limited degree.

Thus, it would appear, that all the evidences, direct as well as presumptive, tend to prove this leading peculiarity with respect to the animal inhabitants of the waters which surrounded the globe during the period of non-rotation, while as yet there was no atmosphere, and "darkness was upon the face of the deep." In the sequel of this section I shall endeavour to show, the perfect adaptation of creatures, such as testacea and zoophyta, for performing what was then in progress of execution—and at the same time point out the incapability of forms possessing locomotion, in the plenary sense of the term—either to have performed that work, or to have existed in the then condition of the world.

Meantime, perhaps, the strongest light in which the question can be put—after what has been adduced—would be to imagine the difficulty attendant on any attempt to wrest the mass of evidence, which can be collected on the subject, so as to *sustain the opposite* position; to endeavour to prove, that the animals of the primitive ocean were possessed of the faculty of moving themselves, at will, from place to place; and that, too, when from the concomitant circumstances of the period alluded to, every part of the circumfluent ocean must have been as nearly as possible alike.

Before leaving this part of the subject, I would take occasion to point out with precision, that what has been said has had no reference whatever to the fossil remains of those extinct monstrous animals which have been discovered in the tertiary and other recent strata. They, too, have been extirpated by a fiat of the Omnipotent, but this originated, I firmly believe and trust, hereafter, satisfactorily to prove, from a very different cause.

SECTION I.

THE ANIMAL EXISTENCES OF THE NON-ROTATORY PERIOD.

CHAPTER II.

Review of the progress made in the previous Chapter. Followed up by exhibiting the description of Fossil Animal Remains which have been discovered in the older formations. Consolidated Lists of their Exuviæ from the Chalk downwards. General Notices respecting the same. The whole compared with the Animal Remains which, by dependance on Scripture, might have been expected to have been disimbedded from the older strata, and found substantially, and with few exceptions, to correspond. Some Explanations respecting the points of disagreement. Remains of Vertebrate Animals discovered in localities supposed to belong to the formations of the Anti-rotatory Period.

We have thus, step by step, and by the most careful investigation, reached another resting-place on our onward and upward course. At the previous stage we became acquainted with the necessary conditions of *animal life*, and wherein it differs from mere *vegetable existence.*

We have since been assured by the concurring testimony of some of the most accomplished naturalists of the age, that several extensive and numerous sections of the animal kingdom are *entirely destitute of the faculty of locomotion*, and others of it, in its plenary signification; and consequently all alike independent of atmospheric air. In very many and very important instances this fact is spontaneously and directly asserted. In other cases it is as conclusively inferred; while, with respect to those extinct races where no direct proof can be adduced on either side, all the attendant circumstances of the several instances, and the reasoning founded on them, concur in evidencing that they, too, pertain to that great division of *animals which live, but do not freely move:* and thus completing, by those concurring testimonies, the proofs in favour of the concluding part of the *hundred and thirty-first* Theorem: *although it is extremely difficult to draw the line with perfect precision which separates the beings possessed of locomotion from those which are fixed, yet, such a distinction does actually exist, and is, therefore, capable of being delineated.*"

Had it been merely to establish the fact of the existence of animal forms destitute of the power of voluntary motion, I might have rested satisfied with what has been accomplished; but, when it is considered how studiously the whole division of creatures so constituted seem to have been excluded from the command, which,

on the fifth day of the Mosaic week, called into existence "the moving creature that hath life;" and then take into account, how clearly and how conclusively, by the assistance of the most eminent and searching naturalists, the fact has been established of there being so many distinct tribes of *Testacea* and *Zoophyta*, which *did not, indeed could not, have sprung into being on the promulgation of that command* which called forth forms, possessing a faculty to which they cannot make pretension—there can be little hesitation in admitting that the *immovable creatures, and creatures with restricted power of motion, had been willed into existence before;* and, strange as the means may appear, that they, nevertheless, formed part of the agency employed by the Omniscient Creator "in the beginning, when He created the heavens and the earth." Nor should any limitation of our own mental capacity be permitted so far to derogate from a just appreciation of the attributes of God as to cause us to hesitate in admitting this assumption, which our judgment, founded on the palpable evidence of the senses, so clearly demands. No man, endowed with reason, for an instant doubts or pretends to deny that the world in its finished state, with all its inhabitants, are the workmanship of God; an irresistible concession which confessedly implies His power (when required for the accomplishment of ulterior plans), to have exercised what, to us, appears a minor degree of creative energy; if, in reality, it *can* be considered a more restricted manifestation of wisdom and power, to constrain a *simpler form* of animal life to work out and accomplish any portion of the great and progressive plan of the Creation! Indeed, it sometimes occurs to me that those who would undertake to prove that it implies, on the contrary, a greater display of power, than to cause more complex animals to perform certain functions, would prevail in the argument.

We must now follow up the 'vantage ground which we have gained, by ascertaining, from the compilations of geologists, what are the *classes, orders, genera,* and *species* of the fossil animal exuviæ which have been discovered embedded in the strata; and, by comparing them with those which we have pre-supposed, to exhibit the analogy which exists between the two—an accordance as perfect as the state of scientific research either warrants or renders desirable; for a nearer approximation, so far from being more conclusive, would, on the contrary, be indicative of a lesser degree of proof, "experience having taught" the most accomplished geologists of the day, "to appreciate, at their proper value, the numberless chances to which organic remains are subjected of being classed in geological catalogues, in situations very different from those which correspond to their true position in nature."*

Referring, with this caution, to the lists given in the Appendix,† a satisfactory coincidence will be discovered between the forms

* MM. De la Beche and Lyell.

† See Appendix C.

which really existed, and those which, by *a priori* deductions, I presumed would—in accordance with the progressive development of the great plan of Creation—be found embedded in the stratified formations of the earth's outer crust during its non-rotatory period.

Confiding implicitly in the announcements of Scripture, I was induced to apply to it, and ask—What description of animal life should be found inhabiting the primeval ocean previous to the formation of the light, and before the Earth revolved around its axis? The clear and unhesitating reply was—All, except *"the moving creature that hath life" dependent on light and air;* for these were subsequently created.

With this answer fresh on the memory, I turned to those naturalists who have given the subject a life-time's attention, and said to them—"Scripture, in whose assertions I repose perfect confidence, informs me that the living being which inhabited the world's ocean before the introduction of light into the material universe, and ere the Earth revolved round its axis, must have consisted alone of those which are either *deprived of locomotion, or possess that faculty restrictedly.* Do you know of any such? what are they? and where do they usually dwell?" The ready and precise answer to those enquiries was—"We do know of many tribes of animals, some of which are totally incapable of locomotion, while others possess it only in a slight degree. They are all inhabitants of the water; and we have classed them under the distinctive groups of *Zoophyta, Radiaria, Conchifera,* and *Mollusca.*"

Assured by this impartial and spontaneous testimony that numerous families of creatures of the description sought actually exist, that they are all exclusively inhabitants of the water; and having learned their distinctive congregate appellations, I passed on to another department of the learned and the laborious in research, and entreated them to inform me, what description of animal life do the petrified remains which they have met with embedded in the successive layers of the earth's outer crust, reveal to them to have chiefly inhabited the water, during the period when those rocks were being deposited and indurated. The reply which they gave, after referring to the tabulated lists which they had compiled during their geological investigations, has been submitted in the Appendix, and is found to be, as near as possible, a counterpart of the answer received to my previous enquiry.

The majority of the living forms made known to us by their exuviæ seem to have belonged to that great division, inhabitants of the water, which are either wholly *incapable of locomotion, or whose motions are restricted;* and which, when reduced to scientific classification, range themselves, with a few exceptions, under the orders *zoophyta, radiaria, conchifera, and mollusca.* But, notwithstanding, although by this a general conviction of identity is borne in upon the mind, and leads to so much satisfaction; yet, when the

eye runs over the consolidated lists of animal remains, it cannot be concealed, nor will it escape almost immediate observation, that there are serious difficulties to be got over, or to be satisfactorily explained, before the reconciliation can be considered thoroughly complete.

Although comparatively few, and some even of doubtful classification, yet there do appear attached to the bottoms of all lists of organic remains, the names of animals which, during lifetime, were possessed of the power of free and swift locomotion; and, therefore, to the amount of the proof which they afford, contribute to weaken the evidence of those lists (full and complete as they are in every other respect) in favour of the position I am so desirous to establish. They are like "the dead fly in the ointment," which must either be got rid of, or it will spoil the whole. Another difficulty also appears, though not so manifestly, on the face of the evidence adduced, and which might, therefore, escape the observation of general readers, did not prudence and candour induce me to be the first to point it out. I allude to the apparent contradiction which arises, from supposing that the primitive ocean was not composed of *salt water*, whilst the *radiaria, zoophytic, conchiferous, and molluscous exuviæ* discovered in the strata are analogous to the testaceous envelopes of similar animals which now inhabit the present seas, implying a seeming incompatibility between the habits of these two divisions of animal life—the ancient and the modern.

The former, and by far the most formidable difficulty, seems divisible into two distinct parts. First, that which respects animals whose powers of locomotion, from our imperfect knowledge of their construction, cannot be thoroughly ascertained, though no doubt can be attached to their geological position and era; and, secondly, as regards animals whose organs of motion are so perfect, and whose habits are so well known, that no doubt can be entertained as to their power of moving freely from place to place, although their geological position may, for the same reason, be exposed to doubt, and open to discussion. I shall, in the first instance, direct attention to the ultimate division of the case, and after making some brief preliminary remarks, leave the discussion in the hands of those who are better qualified by their experience to conduct it; while I claim the full benefit of whatever reasoning may be found in geological works on the subject; inasmuch as the advantage is clearly on the side of those who contend in favour of the *certainty* of locality and geological epoch of fixed animals, or of such as are of slow and imperfect motion, whose remains can only be found associated with the strata amongst which they had their residence when in life; while, on the contrary, the remains of animals which were capable of moving freely and rapidly from place to place might be, and no doubt are discovered embedded in localities indicative of great divergency in *geological* epoch from that which had witnessed their living existence

on the earth; and, from the same cause, have become greatly misplaced in geological chronology. This will appear much more apparent after having heard the evidences, and having learnt in whose hands I design to leave the case, assured that when their attention has been directed to the point, they will do every justice to the subject, and treat it with the most truthful impartiality.

While, as an earnest of what may be expected, I have much pleasure in giving the following short extracts from some recent works on the subject:—

"We shall now," says Mr. Lyell, "consider in what manner the remains of animals may become preserved in rents or cavities. . . . .

"As caves and fissures may remain open throughout periods of indefinite duration, and may become the receptacles of the remains of species inhabiting a country at very different epochs, it requires the utmost care to avoid confounding together the monuments of occurrences of very different dates. Dr. Buckland, in his indefatigable researches into this class of phenomena, has often guarded with great skill against such anachronisms, pointing out the comparatively recent preservation of some organic relics which have become mingled in a common tomb with those of older date.

"Fissures are very common in calcareous rocks, and they are, usually, in the course of ages, filled up in part by small, angular fragments of limestone, which scale off under the influence of frost and rain. Vegetable earth and land shells are washed in at the same time, and the whole mass often becomes cemented together by calcareous matter dissolved by rain water, or supplied by mineral springs. In an uncultivated country the edges of such fissures are usually overgrown with bushes, so that herbiverous animals, especially when chased by beasts of prey, or when carelessly browsing on the shrubs, are liable to fall in and perish. Of this kind is a fissure still open in Duncombe Park, in Yorkshire, where the skeletons of dogs, sheep, goats, deer, and hogs, have been found lodged upon different ledges that occur at various depths in a rent of the rock descending obliquely downwards.

"Above the village of Selside, near Yugleborough, in Yorkshire, a chasm of enormous, but unknown depth occurs in the scar-limestone, a member of the carboniferous series. 'The chasm,' says Professor Sedgwick, 'is surrounded by grassy shelving banks; and many animals, tempted towards its brink, have fallen down and perished in it. The approach of cattle is now prevented by a strong lofty wall, but there can be no doubt that, during the last two or three thousand years, great masses of bony breccia must have accumulated in the lower part of the great fissure, which probably descends through the whole thickness of the scar-limestone to the depth of perhaps five or six hundred feet.'*

"It will appear evident," observes the same gentleman, in another of his works, "from what we have said in the second volume respecting the fossilization of terrestrial species, that the imbedding of their remains depends on rare casualties, and that they are for the most part, preserved in detached alluvions, covering the emerged land, or in osseous breccias and stalagmites formed in caverns or fissures, or in isolated lacustrine formations. These fissures and caves may sometimes remain open during

* Principles of Geology, vol. ii. pp. 225—227.

successive geological periods, and the alluvions, spread over the surface, may be disturbed again and again, until the mammalia of successive epochs are mingled and confounded together. Hence we must be careful when we endeavour to refer the remains of mammalia to certain tertiary periods, that we ascertain, not only their association with testacea of which the date is known, but also, that the remains were intermixed in such a manner as to leave no doubt of the former existence of the species."*

Sir Henry de la Beche says—

"By some it will be considered that too much space has been allotted to lists of organic remains in the following pages; . . . . for practical purposes, however, there was no alternative between rendering them as perfect as the author's means of information would permit, or of omitting them altogether. It must, however, be confessed that, though constructed, apparently, from the best authorities, these lists require severe examination; for, unfortunately, the study of organic remains is beset with two evils, which, though of an opposite character, do not neutralize each other so much as at first sight might be anticipated; the one consisting of a strong desire to find similar organic remains in supposed equivalent deposits, even at great distances; the other being an equally strong inclination to discover new species.

"There can be little doubt that from these and other sources of error, the same organic remains, particularly shells, often figure in our catalogues under two names; and that the exuviæ of certain animals are marked as discovered in situations where they have never been found. Notwithstanding these difficulties, it will, however, be evident, from a glance at the catalogues of organic remains, that a great mass of information has been gradually collected on this subject alone, from which the most important results must follow, even though the various lists may require considerable correction."†

And, more recently, the following ingenuous confession of another geological naturalist is much to the same effect:—

"If, therefore," says Mr. Ansted, "in spite of the advantages of the pretty accurate mapping of Europe, and the detailed and minute knowledge of a positive kind which we possess geologically, there is still doubt and hesitation in determining the ancient history and the exact succession of deposits, it may well be supposed that not less, but much greater, difficulty exists with regard to other countries (India and China for example), of which we know far less."

And again,

"Man may at some future day be able to comprehend this great plan of development (that of ancient animal existence); but he is not yet in that condition, and in his attempt to include its laws within the compass of his imagination, and express their true relation in language, he has hitherto always failed."‡

The convulsions and revolutions of the geological world," observes Mr. Miller, "like those of the political, are sad confounders of place and station,

* Manual of Geology, 2nd edition, vol. iii. p. 60.
† Manual of Geology, 2nd edition, Preface, pp. v. vi.
‡ Ancient World, 1847, pp. 329, 382.

and bring into close fellowship the high and the low; nor is it safe in either world—such have been the effects of the disturbing agencies—to judge of ancient regulations by existing neighbourhoods, or of original situations by present places of occupancy. 'Misery,' says Shakspeare, 'makes strange bed-fellows.' The changes and convulsions of the geological world have made strange bed-fellows too. I have seen fossils of the upper lias and of the lower red sandstone washed together by the same wave out of what might be taken, upon a cursory survey, for the same bed, and then mingled with recent shells, algæ, branches of trees, and fragments of wrecks on the same sea beach."*

These evidences, when taken at their full value, and considering by whom they are given, will go a great way to remove any unnecessary anxiety as to the prejudicial influence which it might have been feared the affixation of a few names of *Reptilia* to the lists of organic remains of the several formations would have occasioned. For, by what has been said, it is evident that numberless accidents may have entombed the remains of reptiles very distinct in geological epoch; or, what is the same thing, much earlier in rocky stratification than their true epochs, when the places which they inhabited during their existence on the surface is duly taken into account.

With respect to the other division of this same difficulty—namely, the discovery of animal exuviæ in situations of which there can be no doubt as to geological correctness, although from the paucity of our knowledge of their individual conformation and habits there may be serious doubts as *to their having possessed the power of locomotion, in its proper signification*—it appears to me, that the strongest line of defence which can be taken up is to express a firm conviction that no animal which encrusted the bottom of the ocean during its period of non-rotation was, or could be, possessed of the faculty of freely moving from place to place; that such ability was alike inconsistent with, and would have been prejudicial to the development of the great plan of Creation; that locomotion, where all the surrounding elements were entirely similar, would have been a superfluous endowment, and, therefore, was not conferred; and finally, *without an atmosphere there could have been no voluntary motion impelled or sustained by aerated blood.* With these declarations this point will be thus left to clear up itself when the great Scriptural announcements of the plan of Creation shall be better understood, more faithfully applied to the researches of philosophy and science, and more generally believed in. *Then*, there is little doubt, those seeming anomalies will give place to juster views, and to more correct classifications; so that what now threatens to be a serious difficulty, will wholly disappear, and give place to a perfect, consistent, and convincing system of Cosmography.

In noticing the remaining point in doubt, namely, the con-

* Old Red Sandstone, 3rd edition, p. 156.

flicting circumstance of the primitive waters being considered to have been fresh, while numberless remains of exuviæ correspond to living congenors inhabiting our present briny seas, I have to allude to the minuteness of the difference of conformation which might enable a conchifer or mollusc to inhabit fresh water, and to point out, *that the primitive ocean contained all the elements of its present saline nature, although differently combined*, and then to give the following conclusive extract from one of our most argumentative geologists, which seems to have been written so expressly for the occasion, although he was then treating of the origin of the Paris and Isle of Wight basins, that with it I shall close this part of the evidence:—

"The sources of the organic fossils," says Dr. M'Culloch, "are no less obvious. But I must not pass from these without inquiring into their value in determining the *marine* or *other nature* of these strata. This is especially necessary, as the theory, and the mistakes of fact, together, have been among the chief sources of erroneous judgment in these cases, and will remain so as long as this engrossing pursuit shall occupy all the attention of geologists, and this hypothesis shall continue to rule. If to mistake respecting a fish has been sufficient to confound the class of Oeningen, it is easy to see what more may have happened and may happen again; not only in such instances, but in the judgment respecting alternating deposits.

"I do not give catalogues of species and genera. . . . I shall only, therefore, name among the living genera of fresh water *Lymneus*, *Planorbis*, *Physa*, *Paludina*, *Ampullaria*, *Cerithium*, *Melanopsis*, *Melania*, *Nerita*, *Cyclas*, and *Unio*. Of these *Lymneus*, *Planorbis*, *Physa*, *Paludina*, *Cerithium*, *Melanopsis*, *Melania*, and *Nerita*, are found in the fossil state; and *Paludina*, *Ampullaria*, *Cerithium*, *Melania*, and *Nerita*, are common to fresh and salt water. Of the shells called exclusively *marine*, *Modiolus*, *Mytilus*, and *Corbula*, live in fresh water; and different species of *Anodon*, *Cyclas*, *Unio*, *Tellina*, *Cardium*, and *Venus*, some belonging to fresh and others to salt water are found promiscuously in the Gulph of Livonia. Our own muscles and oysters, and many more, thrive better in fresh water than in salt; and reversely, many fresh water shell fish can live in salt water, and those of salt marshes are especially indifferent on this subject."*

* Geology, by Dr. M'Culloch, vol. i. pp. 327, 328.

SECTION I.

THE ANIMAL EXISTENCES OF THE NON-ROTATORY PERIOD.

CHAPTER III.

Adaptation of the Apulmonic Invertebrate Animals to the state of the creation previous to the Earth's rotation around its axis. Origin of Calcareous Rocks, and the influential part which the primitive Animal Organisms performed in producing them. Increase of these rocks in an ascending series. Evidences for their existence deduced from geological writers. And a summary of the subjects treated of in this section, with an application of the whole to the progressive development of the Dynamical Theory.

The information, respecting the circumstances connected with animal life at the period to which allusion is now made, having been brought to a point which permits the general argument to proceed, I shall endeavour, in the next place, to make apparent the perfect adaptation of the description of *animals*, which are considered to have existed, to the then condition of our planet, on the supposition already assumed, *of its being unilluminated, without rotation, and enveloped by an atmosphereless ocean, differing in composition from what it does at present*, and, afterwards, I shall adduce some of the more apparent reasons why animal life should at that period have been confined to beings of simpler conformation, and, comparatively, of sedentary habits. In developing this plan of procedure I shall commence by showing the nature and functions of *lungs* and *gills*.

"The aerating organs of animals," says Dr. Fleming, "may be divided into two kinds, *lungs* (pulmones), and *gills* (bronchiæ), both destined to accomplish the same end. The lungs are suited for bringing free air into contact with the blood, and therefore belong to those animals which have their residence on land. The gills are calculated to separate air from water, with which it is always united, and bring it into contact with the blood, and belong therefore to those animals which reside in the sea or in fresh water. . . . .

"Whether the aerating organs be lungs or gills, it appears to be the object of nature in their construction to expose a large surface to the contact of the air. This object is accomplished by their division into numerous cells and leaf-like processes, or by their extension on the walls of cavities, or the surface of pectinated ridges. The blood brought to the organs by the pulmonic vessels is there distributed by their terminating branches. Although still retained in vessels, it can, nevertheless, be easily acted upon by the air on the exterior."*

* Philosophy of Zoology, vol. i. pp. 348, 349.

After describing the accompaniments to those important organs, Dr. Fleming further observes:—

"In order to ascertain the changes which the blood undergoes when thus exposed to the influence of the air, it will be necessary to attend, in the first place, to the changes produced in the air itself. . . . . . It is observed that the air which is alternately inspired and ejected becomes unfit for future use; and is likewise rendered incapable of supporting combustion. The analysis of this altered air indicates the change to have taken place in its oxygenous portion. A part thereof has disappeared, and an equal bulk of carbonic acid is found occupying its place. The quantity of oxygen in this carbonic acid is equal to that which has been abstracted from the air. In this case, either carbonic acid escapes from the blood and an equivalent bulk of oxygen is absorbed; or, the blood furnishes the carbon only, with which the oxygen of the air unites. The former supposition was long countenanced by chemists; the latter is at present the prevailing opinion."*

"In respiration or breathing," says Mr. Hugo Reid, "the oxygen of the air is diminished one-third in quantity; and, either it is converted into carbonic acid by combining with carbon in the lungs; or, the oxygen of the air is absorbed and retained in the lungs, and carbonic acid is given off; or, both take place, so much oxygen being absorbed, and so much being given off in the state of carbonic acid. It is not certain which of these is the true theory of respiration, but it is certain that carbon (in union with oxygen) is expelled from the lungs during respiration. . . . And there seems reason to believe that the main use of respiration is to expel a superfluous quantity of carbon from the body, and that the oxygen of the air effects this by uniting with the carbon, and thus converting it into a gaseous substance (carbonic acid gas), in which form it is more easily got rid of."†

And thus is proved, in the words of the *hundred and thirty-eighth* Theorem "*that* ANIMAL RESPIRATION, *which consists in the alternate inhalation of a portion of air into the lungs, its transformation there, and subsequent exhalation, occasions, by means of the diffusion principle of gases, and of membraneous endosmose a reinvigorating interchange of gases. The oxygen of the atmosphere abstracting and occupying the place of the carbonic acid of the venous blood, which acid is exhaled in a gaseous form.*"

The next process to which I shall have occasion to direct the attention for a moment, is the formation of the shelly substance which constitutes the envelope, or, as it has by some been called, the external skeleton of the conchiferous molluscs, and other descriptions of marine animals. Messrs. Todd and Bowman say—

"Among the invertebrated classes there are hard parts . . . which serve as bases of support for the soft parts. . . . The calcareous plates of the star-fish *(asterius)*, and sea urchin *(echinus)*, the hard coriaceous covering of insects, the hard external integuments of crustacea, and the infinitely various shells of the gasteropoda and conchifera, must all be regarded in the light of hard parts performing the offices above referred to."‡

* Philosophy of Zoology, pp. 350, 351, and 137th Theorem.
† Lectures on Chemistry, pp. 61, 62.
‡ Physiology and Anatomy of Man, vol. i. p. 79.

Dr. Fleming asserts—

"That the most important appendix to the skin of the molluscous animal appears to be the *shell*. This part is easily preserved, exhibits fine forms and beautiful colours, and has long occupied the attention of conchologists. The matter of the shell is secreted by the *corium*, and the form which it assumes is regulated by the body of the animal. It is coeval with the existence of the animal, and appears previous to the exclusion from the egg; nor can it be dispensed with during the continuance of existence. The solid matter of the shell consists of carbonate of lime, united with a small portion of animal matter, resembling coagulated albumen.

"The mouth of the shell is extended by the application of fresh layers of the shelly matter to the margin, and its thickness is increased by a coating on the inner surface. These assertions are abundantly confirmed by the observations of Reaumer, whose accurate experiments have greatly contributed to the elucidation of conchology. If a hole be made in the shell of a snail, and a piece of skin be glued to the inner margin so as to cover the opening, the shelly matter will not ooze out from the broken margin of the fracture and cover the outside of the skin, but will form a coating on its inner surface; thus proving it to have exuded from the body of the animal. . . . .

"The most simple form," says Professor Ansted, "in which an animal constructs a shelly habitation consisting of a number of compartments may be understood by examining any univalve shell. The greater part of the animal is enclosed in a muscular sac called a *mantle*, capable of depositing carbonate of lime.

"As soon as one coat is deposited, which, of course, assumes the shape of the muscular mantle, the simple shell is perfected. If, as the animal grows, it is developed in a spiral form, the shell increases at the aperture; but if the extremity does not adapt itself to the original shell, and remains always of the same size, it must, as it increases, withdraw itself from its former compartment, and build a wall of partition, and in this way we have the first step towards the formation of the shell of the ammonite or nautilus, &c."*

Dr. Ure says—

"Marine shells may be divided, as Mr. Hatchett observes, into two kinds; those that have a porcellaneous aspect with an enamelled surface, and, when broken, are often in a slight degree of a fibrous texture; and those that have generally, if not always, a strong epidermis, under which is the shell, principally or entirely composed of the substance called nacre, or mother-of-pearl.

"The porcellaneous shells appear to consist of carbonate of lime, cemented by a very small portion of animal gluten. This animal gluten is more abundant in some, however, as in the patellæ.

"The mother-of-pearl shells are composed of the same substances. They differ, however, in their structure, which is lamellar, the gluten forming their membranes regularly alternating with strata of carbonate of lime. In these two the gluten is much more abundant."†

"Testaceous shells," says Capt. T. Brown, "are composed of carbonate of lime, combined with a small portion of gelatinous matter; while those

* Ancient World, pp. 243, 244.

† Chemical Dictionary, p. 741.

of the crustacea are composed of phosphate of lime, along with the animal matter. Testaceous shells are, in general, permanent coverings for the inhabitants, and the animal is of a soft simple nature, without bones of any kind; and attached to its domicile by a certain adhesive principle possessed by some of the muscles. . . . . . The shells of crustaceous animals are produced all at once; those of the testacea evidently are formed by the animal gradually adding to them either annually or periodically."*

Carbonate of lime, according to the concurring testimony of all chemists, is composed of 43.6 of carbonic acid, and 56.4 of lime.†

"M. de la Beche has recently published a list," says Professor Buckland, "of the specific gravity of living shells of different genera, from which he shows that their weight and strength are varied in accommodation to the habits and habitations of the animals by which they are respectively constructed. . . . . . The greatest observed density was that of a Helix, the smallest that of an Argonauta. The shell of the Ianthina, a floating, molluscous creature, is among the smallest densities. The specific gravity of all the land shells examined was greater than that of Carara marble; in general more approaching to Arragonite. The fresh water and marine shells, with the exception of the Argonauta, Nautilus, Ianthina, Lithodomus, Haliotus, and great radiated crystalline Teredo from the East Indies exceeded Carara marble in density. This marble and the Haliotus are of equal specific gravities."‡

These expositions, therefore, show:—1st. That the principal end attained by pulmonic respiration is to throw off, through the medium of carbonic acid, a superfluous quantity of carbon from the circulating system. 2nd. That respiration by lungs necessarily implies the residence of their possessor in atmospheric air. 3rd. That the *conchifera, mollusca, cirripeda, zoophyta,* and *radiata* are not furnished with lungs, but with bronchiæ of an extremely rudimentary description, even in most of these classes; that they are principally situated *within* their shelly cavities, and are subject to the will of the animal. 4. That the *testacea* secrete their shelly coverings, by means of the *corium,* by additional layers from within, to which they are continually adding. And lastly. That the shells of *testaceous* tribes are principally composed of carbonate of lime, which, in turn, is a composition of carbonic acid and lime, in the proportions of 44 and 56 in 100 parts; while the density, generally, of these shelly envelopes exceeds even that of Carara marble.

An intimate connexion seems thus evidently to subsist between the non-existence of an atmosphere, the want of lungs, and the formation and *secretion* (not the exhalation) of carbonic acid; for, had carbon been *required to have been ejected* through the medium of carbonic acid; lungs would not have been denied to the tribes which then inhabited the water; and if lungs, then a corresponding at-

* Conchologist's Text Book, p. 12. Theorem 157.
† Dr. Ure's Chemical Dictionary, p. 245, &c.
‡ De la Beche's Geological Researches, 1834, p. 76.

mospheric medium. But so far from lungs and an atmosphere being then conducive to the plans of the Creator, they would have been positively inimical, and therefore, were withheld; for the great object *then desired was the formation of carbonate of lime.* And carbonate of lime was actually being accumulated by *the instrumentality of the internal functions of the testaceous tribes;* while it was, at the same time, being transformed into their beautiful, secure, and convenient envelopes; thus exhibiting the goodness, blended with the wisdom of God, for that which afforded support, fixity, and defence against the pressure of the surrounding element to these ancient submerged animals, was also so disposed as *to yield carbonate of lime in a ratio equal to that which the periphery bears to the central bulk of any form whatever.*

We have only to extend our researches a little farther, to be convinced of the perfect adaptation of the means to the end, and of the harmony which prevailed between the state of animal life and of the earth at the period I allude to; for, it will be remembered, that carbonate of lime is composed of carbonic acid and lime. The source and application of the carbonic acid have been satisfactorily explained; to account for the lime, we must come to the unavoidable conclusion that its component elements were absorbed or extracted from a menstruum holding it in combination; for living creatures which were either altogether fixed, or possessed only of restricted power of motion, and surrounded by a tranquil medium, had no other means of being supplied with the elements of lime than by the water in which they were immersed, while the tidal fluctuations of the primitive ocean, occasioned by luni-solar influences, would be the means of bringing successive parts of the water within the reach of those which were absolutely fixed, and enable them to extract those elementary principles necessary for the formation of carbonate of lime—an assumption corroborated by the fact, *that whatever may be the diversity of their form, or their other constituent characteristics, carbonate of lime is invariably found to compose a great proportion of their fossilized remains.*

The operation alluded to, so essential for their own well-being; so admirably adapted for the great end in view—that of combining in them, and by means of their animal secretion, the requisite proportions of calcium with carbonic acid; perhaps I might even go farther, and say, the formation by animal agency of *calcium* itself, and then effecting its union with carbonic acid—not only tended to abduct from the ancient ocean the primary elements necessary to effect those purposes, but by locking them up together, rendered them innocuous and insoluble, and capable of being preserved in that condition for the requirements of future beings. The water was drained of elements which, if left uncombined, would have been positively hurtful to future life; while, at the same time, the disturbance of the chemical equilibrium thereby effected, greatly

tended, simultaneously, to promote the precipitation of other materials from the ocean holding them in combination.

I wish it particularly to be borne in mind, that the perfect adaptation of the species of animal life to the then condition, and to the progressive development of the earth's material crust, was one of the means which most effectually promoted and accelerated the whole operation.

By its being so planned, that the superfluous, and consequently the otherwise injurious portion of carbon taken into the animal circulation should be got rid of, not by ejection, as now done through the medium of gills and lungs, and by combination with the oxygen of atmospheric air, but by internal secretion, and being by the agency of the corium formed into carbonic acid, and united with calcium into carbonate of lime, the sub-aqueous surface of the earth,—wherever deemed requisite,—became gradually enveloped by a calcareous crust composed of the exuviæ of myriads of marine testacea, wonderfully destined, while enjoying the successive functions of their degree of animal life, to promote the plans of the Creator. These slow, but unerring instruments in the work of calcareous elaboration, at the same time that they were encoating themselves in their variegated shelly defences, unitedly encrusted that portion of the sub-oceanic surface to which many of them were affixed for life, and others nearly so, by the unalterable and wise decree of the Omnipotent. While they were thus destined and occupied, and well adapted by their species to the then condition of the surrounding creation, there appear to have been other concomitant objects wrought out by the agency of those animal elaborators. They were, as I have already so frequently asserted, and shall, by and by further insist upon, the only means which could be employed to disturb the chemical equilibrium of the water, and thereby, to promote precipitation of other elements besides those required for their own outward defences. They were also producing and accumulating *molluscous animal matter*, of which one peculiar ingredient, after they had become extinct, assumed almost an etherial buoyancy, and ascended through the mass of waters to the very surface; nay, I might even venture to assert, throughout the whole of intervening space, to constitute the material bases of the etherial fluid, or of the primary light; there to await the further development of the great plan of Creation. All these ends, so essential to the object then in view, seem to have been intimately connected with partial or total *immovability* of construction; *fixation*, or degrees of fixation, could alone ensure the encrusting of the earth *where* such was necessary. The *profundity of the ocean* was the only locality where this could be done by a living agency; *Water* the only medium for holding the requisite component elements in suspension, in equality throughout, and in adaptation for being readily imparted in the quantities and proportions required by animal life successively developed;

Vacuum, or the absence of the atmosphere, the most effectual means for the perfect retention of these accumulated exhalations, associated with the primitive waters; whilst, as regards its inhabitants, fixation being so indispensable, movement or fluctuation of the surrounding and containing fluid became as essential; hence the adaptation of the luni-solar current, which, even before the illumination of the sun, or the diurnal motion of the earth, must have been continually flowing round the non-rotating sphere.

Fortunately for the perfect establishment of the position which I have assumed, the presumptive evidence arising by contrast from the supposition of an opposite state of animal life during the period alluded to, when the several suits of strata were in progress of formation and enduration, is as conclusive in my favour. Animals endowed with locomotion (even could they have existed, which, before the atmosphere was formed, was impossible), would not have been adapted for the object designed. Had they been swift, free, swimming creatures, they must have been of nearly equal specific gravity with the element in which they moved; consequently, could not have been encased in a shelly coating of carbonate of lime weighing 2.7, or nearly three times the weight of the same bulk of water.* Deprived of this solid covering they would have left no calcareous exuviæ to promote the object for which the *testacea*, *zoophyta*, &c., were willed into existence. Had they been without this shelly defence against the pressure of an ocean, such a state would have been inconsistent with the goodness of God. On the other hand, had they been provided with ponderous testaceous coatings, and at the same time furnished with pulmonary organs befitting locomotion, and endowed with senses, organs, and perceptions of a higher grade of animal life, this condition, also, would have been at variance with our conceptions of the justice and benignity of the common Creator of the universe. For, how nugatory would have been the power of freely moving at will, whilst under such a load, without the requisite atmospheric air or light to have enabled them to use these faculties of motion!

Nor will the difficulties, under this suppositional view of the case, be in any degree lessened by supposing that many of the animals of the primitive ocean were akin to the *Cephalopoda*, such as the ammonitic exuviæ have led some to suppose; for even in that case, they would have been dependent on atmospheric air to have assisted them in transporting freely from place to place their shelly abodes—a dependence which puts an end to the supposition of such a conformation, the atmosphere not having been then in existence. On the other hand, all these irreconcilable anomalies vanish when it is assumed that the living creatures, which dwelt at the bottom of the primeval waters, consisted of those which were either incapable of locomotion, or only partially endowed with that faculty, and im-

* Ure's Chemical Dictionary, p. 245.

pelled by water. *Their* conformation and habits were in perfect accordance with the state of the world at that time, and with all its attendant circumstances. Light and darkness were equally the same to them. They were not dependent on atmospheric air. Their wants were amply supplied by the carrier water wherein they dwelt; whilst, in the particular instance alluded to, all that was going on *within* these zoophytic and testaceous creatures, *every atom of matter which they assimilated to their molluscous bodies, or to their zoophytic or testaceous coverings, was an atom added to and towards the promotion of the work then in progress:* for ages every pulsation which took place in their imperfect circulating system along the whole underline of the dark and silent waters was a beat towards the accomplishment of the great plan of Creation! And, when that work was so far accomplished as afterwards to admit of its being completed, and when it pleased the Omnipotent to reveal to us the very words in which His commands were given for that purpose, no discrepancy is found even there, between what I have supposed and what actually took place: for, with an evident foreknowledge of their pre-existence, they were studiously and deliberately excluded from the Command which, on the fifth and sixth days of the Mosaic week, willed all the remaining tribes of animal beings into existence. True to the fiat of the Creator, "*the waters*" and "*the earth*" produced on those days "the moving creature that hath life; fowl that may fly in the open firmament of heaven; cattle, and creeping thing, and beast of the earth after his kind;" all of them being *animals possessing powers of free locomotion, dependent on atmospheric air and influences;* and which, in union with those previously created "*in the beginning,*" completed the animal kingdom, as it is now known to be.

As a summary of the whole of this part of the argument, while I firmly assert that the primeval atmosphereless waters were the abode of innumerable tribes of living creatures, I as firmly believe that not one of them could accelerate its own movements at will by means of aerated blood; and, although myriads of animals had, for ages, encrusted the bottom of the ocean, there was not, until the fifth and sixth days of the Mosaic week, a pair of perfect gills or lungs within the whole range of the solar system!

After what has been so clearly and circumstantially stated, and considering the lists of organic remains which have been adduced, it is not very probable that any well-founded doubt can exist respecting the origin of the calcareous formations; or the important part which the exuviæ of marine animals have exercised in their construction; yet, to defend myself against the possibility of any such lurking suspicion in the mind, and to put the matter in the clearest possible point of view, I shall have recourse to part of the *sixteenth* Theorem, and to some of its innumerable authorities. The former asserts—*That with the exception of some of the inferior, the stratified rocks contain innumerable vestiges of vegetable, animal, and*

zoophytic remains. . . . . . Some of which are of gigantic dimensions in comparison with recent equivalents. . . . . . And that they have by their exuviæ contributed largely to the formation of the carboniferous and calcareous strata; the calcareous matter increasing in an ascending series, yet found to be, during every epoch, precisely similar in its component elements.

It likewise forms a part of the *hundredth* Theorem, in regard to lime itself, *which is, by many, considered to be the product of animal secretion.* The evidences will be restricted to those having reference to *animal* remains. The fossilized vestiges of *vegetation* will occupy our attention in their proper place. To proceed:—

"The origin of the limestones," says M. de la Beche, "is of far more difficult explanation than the sandstones and slates in which they are included." . . . . . If we attribute the origin of the grauwacke limestone in a great measure to the exuviæ of testaceous animals and polypifers, we must grant the animals carbonate of lime with which to construct their shells and solid habitations. This they may have obtained either in their food, or from the medium in which they existed. . . . . . Indeed it would appear that we should look to the medium in which testaceous animals and polypifers existed, for the greater proportion, if not all, of the carbonate of lime with which they constructed their shells and habitations.

"That the animals, by secreting carbonate of lime from the medium in which they lived, somehow contributed considerably to the mass, we are certain, as their remains now constitute a large portion of it."*

And again M. de la Beche proceeds:—

"To discover that there may have been some connection between the animals with solid parts, and a facility of procuring carbonate of lime on the surface of the globe, appears perfectly consistent with the design manifested in the creation; because it assumes such design at all periods, and constant harmony between the forms of creatures and their mode of existence. If we imagine a mass of animals to be suddenly called into life, each properly provided with its solid parts, the carbonate of lime contained in these bodies would no doubt be sufficient for a constant quantity of the same animal during a succession of ages; for, by devouring each other, this necessary substance would be transmitted from one creature to another. We are, however, certain that this has not been the case; for the solid parts of animals which have been successively imbedded in various rocks, constitute a very large proportion of certain of those rocks, and, if withdrawn from the fossiliferous deposits generally, would very considerably diminish their thickness. Therefore, if the exuviæ of animals had not been entombed, and if the supply of carbonate of lime had not been greater than that which could have been derived from a mere destruction of one animal by another for the purpose of food, the surface of our planet would not have been what it now is; and, consequently, the fitness of things for the end proposed being constant in creation, the general condition of animal and vegetable life would not have been such as we now find it.†

The opinion of Dr. M'Culloch respecting the origin of limestone

* Manual of Geology, p. 451. † Ibid, p. 459.

formations is very interesting, as he has directed his attention closely to that branch of geological research; and, with much satisfaction, therefore, I have selected the following apposite passages from amongst innumerable others, in his last publication:—

"The formation of coral islands proves that enormous and solid masses of calcareous rock are the produce of animals alone; and when we reflect on the magnitude of some of these, we have no reason to be surprised at the extent of those rocks which, among the secondary strata, are composed chiefly of shells. Were we even to suppose that every particle of the largest bed of limestone known was originally part of a shell, we should, as far as the bulk of the mass is concerned, assume nothing that would be discountenanced by the magnitude of the great coral reef of New Holland. If the most minute animals of creation can thus by their numbers execute, unassisted, works of such enormous magnitude, and, as navigators think, within spaces of time comparatively limited, it is far from unreasonable to believe that the succession, through unnumbered ages, of animals so far exceeding these in bulk, and in the relative quantity of their calcareous produce, should have generated all the calcareous strata in the secondary series."* . . . . .

The celebrated naturalist Lamark, in one of his works, affords also the following interesting evidence on this point:—

"The *meliolites* is a shell of most singular form, and perhaps one the most interesting to study, on account of its multiplicity in nature, and the influence which it has upon the condition and size of the masses at the surface of the earth, or which compose its external crust. It is one of those numerous examples which prove that, in producing living bodies, what nature seems to lose in size, she fully regains in the number of individuals, which she multiplies to infinity, and with a readiness almost miraculous. The bodies of these minute animals exert more influence on the condition of the masses composing the earth's surface, than those of the largest animals, such as elephants, hippotami, whales, &c., which, although constituting much larger individual masses, are infinitely less multiplied in nature. In the environs of Paris, some species of meliolites are so numerous, that they form almost the principal part of the stony masses of certain ranges."

Mr. Lyell says—

"No shells are more usually perfect than the microscopic, which abound near Sienna, where more than a thousand full-grown individuals are sometimes poured out of the interior of a single univalve of moderate dimensions."

Again—

"The *testacea*, of which so great a variety of species occur in the sea, are a class of animals of peculiar importance to the geologist, because their remains are found in strata of all ages, and generally in a higher state of preservation than those of other organic beings. Climate has a decided influence on the geographical distribution of species in this class; but as there is much greater uniformity of the temperature in the waters of the ocean than in the atmosphere which invests the land, the diffusion of many marine molluscs is extensive."

* Geology, by Dr. M'Culloch, vol. i. pp. 216, 217.

In conclusion Mr. Lyell says—

"So wonderfully minute are the separate parts of which some of the most massive geological monuments are made up! When we desire to classify, it is necessary to contemplate entire groups of strata in the aggregate; but if we wish to understand the mode of their formation, and to explain their origin, we must think only of the minute sub-divisions of which each mass is composed. We must bear in mind how many thin, leaf-like seams of matter, each containing the remains of myriads of testacea and plants, frequently enter into the composition of a single stratum, and how great a succession of these strata unite to form a single group!"*

Mr. Miller, in his usual graphic style, affords the following evidence:†—

"Of late," says he, "the geologist has learned from Murchison to distinguish the rocks of these two great geological periods—the lower as those of the Cambrian, the upper as those of the Silurian group. The lower—representative of the first glimmering twilight of being—of a dawn so feeble that it may seem doubtful whether, in reality, the gloom had lightened—must still be regarded as a period of uncertainty. There is less doubt, however, regarding the existence of the upper group of rocks—the Silurian.

"The depth of this group, as estimated by Mr. Murchison, is equal to double the height of our highest Scottish mountains. And four distinct platforms of beings range in it, the one over the other, like storeys in a building. Life abounds in all these platforms, and in shapes the most wonderful; the peculiar encrinites of the group rose in miniature forests, and spread forth their sentient petals by millions and tens of millions amid the waters; vast ridges of corals, peopled by their innumerable builders—numbers without number—rose high amid the shallows; the chambered shells had become abundant—the simpler testacea more so; extinct forms of the graptolite or sea-pen existed by myriads; and the formation had a class of creatures in advance of the many-legged annelids of the other. It had its numerous family of trilobites—crustaceans nearly as high in the scale as the common crab—creatures with crescent-shaped heads, and jointed bodies, and wonderfully constructed eyes, which, like the eyes of the bee and the butterfly, had the cornea cut into facets resembling those of the multiplying glass. . . . . .

"The locomotive powers of the trilobite seem to have been little superior to those of the chiton (which in many other respects it very much resembled). If furnished with legs at all, it must have been with soft rudimentary membranaceous legs, little fitted for walking with; and it seems quite as probable, from the peculiarly shaped under margin of its shell, formed like that of the chiton for adhering to flat surfaces, that, like the slug and the snail, it was unfurnished with legs of any kind, and crept on the abdomen. . . . . .

"Thus ere our history begins, the existence of two great systems, the Cambrian and the Silurian, had passed into extinction, with the exception of what seem a few connecting links, exclusively molluscs, that are found in

* Principles of Geology, vol. ii. pp. 307—310; vol. iii. pp. 47, 163, 239.

† In order to adapt this passage to my work, and the object I have in view, I have very reluctantly been obliged to abstract it more than I otherwise should have wished. —AUTHOR.

England to pass from the higher beds of the Ludlow Rocks into the lower or tilestone beds of the old Red Sandstone."*

"The exuviæ of at least four platforms of beings lay entombed, furlong below furlong, amid the grey mouldering mud stones, the harder arenaceous beds, the consolidated clays, and the concretionary limestones, that underlay the ancient ocean of the Lower Old Red. The earth had already become a vast sepulchre, to a depth beneath the bed of the sea equal to at least twice the heighth of Ben Nevis over its surface."†

These extracts from the writings of geologists who have given the subject their careful attention, both *in sito*, in the field of labour, as well as in the retirement of their closets, cannot fail to be otherwise than conclusive and convincing to every one *of the paramount influence which the fossil exuviæ of marine animals have exercised in the formation of calcareous strata.*

The derivation of the elements which enter into the composition of the carbonate of lime, of which those remains consist, or whether this, or even calcium itself, be or be not the product of animal vitality and secretion, do not affect the main question so long as it is unanimously admitted by all *that the greater proportion of the calcareous and calcareo-argillaceous deposits are composed of the fossilized remains of what once were living creatures.*

The conclusion which seems so irresistible—that the primitive waters contained the appropriate elements for the sustentation of apulmonic animal life, and that these were gradually abstracted from it by secretion, accords so admirably with the conception of the reciprocal influence of the liquid upon the solid portions of the globe—the one contributing towards the formation of the other, and the perfecting of both being the result of their mutual progress—that they cannot be separated from each other in the imagination. I cannot conceive otherwise than that the deposition from the primitive menstruum was as indispensable towards the purification of the waters, and to prepare them for becoming "*the seas*" of the present day, as that the rocky material was requisite for the completion of the solid strata which was being formed beneath. It was, in fact, the same operation. What the primitive ocean resigned to render it the sea, the mineral bed beneath acquired to solidify it into a rocky stratum; whenever the interchange became sluggish, by the aqueous medium assuming a static condition of equilibrium, to which chemical compounds in large masses are ever prone, fresh excitement was given to the work of progression by the creation of a more searching and influential race of animal existences. The equilibrium by this means became disturbed, and the abstraction and solidifica-

* Note by Mr. Miller. "Upwards of eight hundred extinct species of animals have been described as belonging to the earliest, or Potozoic and Silurian period, and of these only about one hundred are found in the overlying Devonian period, while but fifteen are common to the whole palæozoic period, and not one extends beyond it." (*M. de Verneuil* and *Count D'Archiac* quoted by Mr. D. T. Ansted, 1844.)

† Old Red Sandstone, 3rd edition, p.p. 266—272.

tion again went on. That this is in strict consistency with the opinions generally entertained at the present day, I must be allowed to insist upon. No one for a moment doubts that the stratified masses underwent a protracted course of progressive preparation to fit *them* for the important part which *they* had to perform in the economy of the earth's formation; and, therefore, there is no just cause to deny to the less consistent oceanic waters, which also were from "the beginning," the necessity of undergoing some analogous process of preparation to enable *them* also to perform *their* part in the newer economy, when the earth should be no longer slumbering without rotatory motion, and bearing them tranquilly over all its surface; but when they should be confined within narrower troughs of much greater profundity, and be the limpid, sparkling seas of our present day.

In corroboration of this opinion, I shall, without adducing any of the evidences, recapitulate the words of the *ninety-seventh* Theorem. "*That geologists generally concur in the opinion, that the sea is the residium of a primitive ocean, which, at one time or other, seems to have covered the dry land which now constitutes the habitable surface of the globe. That from it were deposited the mineral ingredients which compose the inorganic portion of the stratiform masses of the earth. That this separation simultaneously prepared the primitive ocean for becoming the present sea. And, lastly, it has been maintained, especially by some of the earlier geologists,* "*That there are no operations now taking place in the sea, which bear the slightest analogy to those productions of mineral substances in strata which took place formerly on our globe.*"

The next point to be considered is the circumstance of the calcareous formations increasing in an ascending series from the grauwacke to the chalk inclusive, and to show its analogy to the natural increase of apulmonic animal life, in order to be convinced that there exists an intimate connection between them.

The horizontality of surface of the primitive earth, assumed to be a perfect sphere surrounded everywhere by an equal depth of water,* entirely precludes any recourse being had to the supposed influence—during the non-rotatory period—of springs, volcanoes, fissures, or disintegration. To be consistent these must all be discarded from the arguments having reference to that period and condition of the globe; whatever disposition there may be to admit the influential part they perform at present, and under entirely different circumstances, in supplying our seas, lakes, and rivers with the calcareous material required by their present inhabitants to fabricate their shelly and beautifully diversified coverings. In the former economy the important uses which were made of apulmonic animal life, testaceous and zoophytic, must be looked to alone for the proper explanation

* The surface of a sphere whose diameter is 8,000 miles, may, for all practical purposes, be considered *level.* When I say "an equal depth of water," I do so irrespective of the luni-solar wave which travelled round the non-rotating earth.

of the phenomenon in question. Deposition from the primeval ocean, chemically charged with numerous ingredients possessing different degrees of affinity for each other, was a principal object sought; but, in a chemical compound of inert matter, when once the affinities of the several ingredients are satisfied or completed (and to this state, after every partial disturbance—whether effected by the abstraction of some materials, or the addition of others—compounds are ever prone to recur), the static condition of the equilibrium they assume, cannot, of themselves, be altered, for "matter can neither generate motion nor change in itself, nor alter the direction or the velocity of that which may be impressed upon it;" and we must, therefore, of necessity, look to some other sufficient cause—a cause independent of the medium itself—for the renewed disturbance of the equilibrium, and the acceleration of the deposition of the material held in solution. It appears, from the concurring evidence of all geologists, that the formation of calcareous matter went on increasing in an ascending series, and a power should be sought for which also went on augmenting. An inert precipitate, falling from a mass where chemical affinity was tending to produce equilibrium amongst its ingredients, would have gradually declined in energy.

A local living agency, radiating from foci of creation, reproducing themselves with that rapidity which comparative security from the rapacity of other creatures permits; coating themselves with carbonate of lime, as they now do, whose component elements were abstracted from the surrounding medium; and, by these increments of abstraction, occasioning a simultaneous deposition of other ingredients from the primitive ocean, seem to fulfil all the conditions of the problem, and to leave no desideratum unsatisfied; so that we can hardly acknowledge the necessity of seeking for any cause beyond the agency of the testaceous and zoophytic animals with which the submarine surface of the earth was densely encrusted; and more especially, as this, which forces itself so strongly upon our notice, may be considered competent to have produced the effect. This conviction will be materially strengthened when I come to adduce the analogous fact, placed on clear, undeniable record, that the waters were commanded, and immediately did produce the more recent congenors of those testaceæ and zoophyta. For, upon the presumed principle *that no secondary agent of the Creator was ever called upon to perform any part of the great work of creation without having the necessary materials placed at its disposal*, analogy leads to the conclusion, that the primitive waters of our sphere, before rotation was impressed upon it, did contain those elements which, by the diligent and enduring agency of the more simple forms of marine animal life, produced those vast and pervading calcareous coatings of the earth's mineral crust which, unless we had known the effects of persevering industry, we might be apt to consider entirely disproportionate to their puny powers.

The consideration of these wonderful facts, however, and of the well-authenticated circumstance of the prevalence at the bottom of the ancient ocean of innumerable living forms, which are known, from their exuviæ, to have encrusted themselves with carbonate of lime, will, when taken in combination, strengthen our belief as to the importance of the labour which they performed, and the danger of either undervaluing it, or of ascribing it to any other origin; otherwise we shall not only overlook a very important and influential secondary cause, but omit to attribute to that cause a commensurate effect. In a subsequent part of this treatise I shall have occasion to show, in continuation of what has already been stated, that, in addition to the work assigned to these successive races and forms of apulmonic creatures—of encrusting the shell of the earth with carbonate of lime at the bottom of the primitive ocean—they were destined, all the while, by the wisdom of the Creator, to produce a peculiar animal secretion, required for the formation of the life-sustaining atmosphere, and designed to be associated in it with another, without which no air-breathing animal could, for one moment, have existed.

And that, however wonderful this arrangement may seem, it is equalled only by the wise forethought which devised that this subtile and buoyant element should, in its primary form, have been produced and set free at the *bottom* of the ocean; its ascent, as it percolated, in that state, through the super-incumbent waters, contributing very essentially to the work of precipitation which was then going forward throughout their whole expanse.

I trust it may not be out of place to endeavour, here, to generalize the evidence which has been gone through in detail, as far as it bears upon the necessity—if I may be allowed so to express myself—for there having been a *succession of sub-marine animal life*, to ensure the success of the co-relative operation during the protracted process of encrustation with calcareous material and the purification of the waters.

The fact of the primitive earth having been enveloped by a menstruum which, *ab initio*, contained the calcareous elements, in chemical combination, when contrasted with that of the ratio of encrustation having kept pace with the increasing power of the water to retain these elements in its grasp, *necessarily implies a change in the intermediate living and operative agency.*

The work *beneath* having progressed in proportion as the reluctance to part with the means went on augmenting *above*, from whence alone the necessary supply could be obtained, there appears to have been no other method, consistent with the laws prescribed for creation, than that of bringing about the double effect then contemplated, short of a change in the agency, and an increase of its power of abstraction and assimilation; an increase of warmth in the containing medium being added as an essential auxiliary. While it ought to

be borne in mind, as an additional reason for coming to this conclusion, that as the waters were undergoing a gradual change, as from Z to A, and the earth, benefitting thereby, was simultaneously altering its state, as from A to Z, the *same* living agency could not, during the whole intervening period, have effected the interchange which was necessary between the two mutating bodies.

In conclusion of this part of my discourse, I hope I have, in the first place, shown the close consistency during the primeval era, between the forms, the nature, and the functions of the living creatures which then encrusted its submerged surface, with the absence of light and of an atmosphere; and not only this, but also the object which was in view, by their priority of existence; inasmuch as they appear to have been the instrumentality made use of to elaborate part of *the material bases* of which the light and the atmosphere are composed.

And, finally, I consider that the exposition given has established, as far as the state of information on the subject will permit, the position assumed at the commencement of this section—namely, *That before the rotation of the earth around its axis, or during the period called in Scripture "the beginning," the primitive, dark, and atmosphereless waters were the abode of innumerable races of living apulmonic creatures, independent alike of light or atmospheric air for life or motion. The greater part consisting of descriptions which either were entirely fixed, or moved but imperfectly;* and *that of these there were several successive generations.* And thereby there has been wrought out, as far as this particular branch of evidence is available for that purpose, sufficient proof *that during the same Scriptural period of indefinite duration, there were formed and forming, by the united instrumentality of animal and vegetable secretion and decomposition, of crystalization, and of ordinary deposition, the materials which were afterwards to constitute all the geological and meteorological phenomena; when they should, by the centrifugal impetus engendered by the protorotation of the earth, be placed in their respective positions. And that, by the same instrumentality, the primitive waters were, likewise, undergoing due preparation for their present condition.* While in effecting this I have manifested the dependence which philosophy ought to have on Scripture, *the position assumed being as consistent with the true meaning of the inspired narrative, as it is accordant with the results of philosophical investigation, and of geological research.*

SECTION II.

THE VEGETABLE ORGANISMS OF THE NON-ROTATORY PERIOD.

CHAPTER IV.

The subject of argument of this section stated. The Vegetation of the Non-rotatory period neither flowering nor seed-bearing plants. Striking analogy in this respect to the Apulmonic Creatures which were the subject of the previous Section, pointing to a common cause; and, therefore, requiring to be treated in a similar manner. The Dicotyledonous class of Plants fully described. The Monocotyledonous also minutely characterized, and both of these great divisions eliminated from the argument, as having been formed during the Mosaic week. These, however, not comprising the entire Vegetable Kingdom, leave the Acotyledons as a residue, which are considered to have been willed into existence during the period of non-rotation. This latter class closely delineated, and their functions particularized.

In following out the plan which has been laid down for the consideration of my subject, the attention must now, for a short time, be directed to an interesting group of natural objects, which contributed very materially to the formation of the stratified masses, not only by constituting, in themselves, the greater portion of the coal-measures, but by the influence they exercised over the imperfect animal life then in existence; and also by occasioning depositions from the surrounding primeval fluid. I allude to the Flora of the ancient world, as represented by the FOSSIL VEGETABLE REMAINS found imbedded in the strata.

It may be as well to explain, that during the protracted period when they existed and grew in succession, the supposed circumstances of our planet are considered to have been identical with those premised when treating of the apulmonic animal kingdom, namely,—*That it was an unillumined sphere, without rotatory motion, and circumbounded by an atmosphereless ocean of considerable depth; higher in temperature, and differing considerably in the combination of its associated elements when compared with the present seas.*

The point, then, to be established is—*That although in the primeval ocean there grew innumerable plants, of which there were several successive creations, yet they did not belong to any class possessing true seeds, or fruits having seeds within themselves, requiring dry land and atmospheric air for their full development and the performance of their several functions.*

This branch of our enquiry is involved in still greater difficulties than the previous one, because there is not, as in the case of the animal creation, a line of distinction so broadly drawn between those objects of the vegetable kingdom which were created at the beginning, or during the period of non-rotation, and those willed into existence on the third day of the Mosaic week. This observation, however, does not imply that the indistinctness of the line of demarcation is attributable to the Creator, to whom the essential difference is clearly known, but to the imperfect intelligence of man in classing those objects into groups even in their recent condition, and much more so in their fossil state; especially when the objects of research approach the boundaries of the lower denominations of plants, in which the absence of flowering and seeding processes and other essential distinctives often leave the investigator at a loss; while the difference between aquatic and terrestrial plants is very indistinctly observed; or rather, not observed at all; the former being associated in the great *class Cryptogamia*, as one of its *orders*.

Despite, however, of these difficulties I trust, successfully to shew that the great mass of fossil plants found in the strata were distinct in their nature and characters from those willed into existence by the concise yet comprehensive words: "Let the earth bring forth grass, the herb yielding seed, and the fruit tree yielding fruit after his kind, whose seed is in itself upon the earth."*

It is when we look at the subject in the point of view in which I have placed it, that a striking analogy is recognized—a strong mannerism, if I may be allowed so to express myself—in the primitive works of creation. There was no atmosphere; and, accordant therewith, the animals were apulmonic, and, consequently, deficient in their power of locomotion. The *plants* had neither flowers, seeds, nor fruits, but rudimentary sporules, possessing neither radicle nor plumule, and, consequently, alike insensible to light or darkness; while none of their processes seemed to have required dehiscence, which can alone be brought into operation by atmospheric air. As there had been a succession of animal life, adapted to the several stages through which the primitive formations passed, and according as the change in the condition of the primitive waters demanded; so, in like manner, there appears to have been a series of changes in the then vegetable kingdom, corresponding to the changes in the condition of the earth. And, lastly, the description of plants discovered in the strata have a close analogy to recent plants of *imperfect formation*, or to those denuded of floral and fructifying, or seeding processes, properly so called; or, in other words, they correspond to those which, under the conceptions formed, might, *a priori*, have been expected to have been found there. Besides, when the result of our previous investigations is applied, there will be found strong presumptive evidence for concluding that all the plants of the pri-

* Genesis i. 11.

meval era were aquatic. The primitive animals were inhabitants of the waters; their remains are found *wherever* geologists have investigated; consequently, the whole globe must, at one time or other, have been under water; and we have therefore no authority for supposing one condition of the earth for the *Animal*, and, at the same period, a different condition for the *Vegetable* kingdom. The proof which goes to show that the earth was circumbounded by oceanic waters in the one case, cannot, as their geological eras were identical, be set aside, or weakened in the other. But, that all may be able to form their opinions on circumstantial data, I shall go on to examine the evidences leading to this conclusion, in doing which, as it will greatly contribute to perspicuity and conviction to adopt such a plan of investigation as shall dispose simultaneously of whole groups of plants, this shall be done accordingly.

Pursuing this method, I shall commence by submitting a brief view of the CLASSES which compose the whole vegetable kingdom, according to the natural system of botany; together with the various *orders*, *genera*, &c., of those which it may be essential to particularize. For this purpose I refer to the concluding words of the *hundred and thirteenth* Theorem; and proceed to give the evidences upon which they are founded.

Professor Henslow says—

"With very few exceptions, nearly all plants may be referred by any botanist at a single glance, and with unerring certainty, to their proper classes; and a mere fragment, even of the stem, leaf, or some other part is often quite sufficient to enable him to decide this question. The names of these three classes are derived from one of the chief characteristics which prevails through *nearly* all the species included under each of them separately. This we shall presently explain; but the reader may understand these names to be DICOTYLEDONS, MONOCOTYLEDONS, and ACOTYLEDONS; and that the two former of these classes have, respectively, the names of *Exogenæ*, and *Endogenæ*. The former being derived from peculiarities connected with the structure of the seed; the latter from a consideration of the internal organization of the plants themselves. . . . . . .

"In the very slight sketch here given of the primary groups under which all plants may be arranged, we have not pretended to notice any terms which different botanists have applied to them; but we shall now collect the substance of what has been said in the form of a table to assist the memory of the reader.

	EMBRYO.	STRUCTURE.	FRUCTIFICATION.
1.	Dicotyledons	Exogenæ	Phenerogamæ
2.	Monocotyledons	Endogenæ	
3.	Acotyledons	Ductulosæ	Cryptogamiæ."*
4.		Cellulares	

The author of the article on Botany, in the Library of Useful Knowledge, when treating of the natural grouping of plants, expresses himself thus:—

* Botany, by Professor Henslow, pp. 30, 37.

"In their internal structure stems are apparently constructed upon several different plans; in the bamboo they are hollow, with transverse partitions; in the cane they are solid, and of an uniform density; in the oak they are hardest in the centre; in the cocoa-nut they are softest in the centre; in many climbers they have an uniform density, and appear pierced with multitudes of cylindrical channels parallel with the bark. In ferns the wood has a singularly twisted appearance; and finally, in many herbaceous plants it seems to consist of a mass of succulent substance, with a few fibres mixed among it. But it has been ascertained that all these variations are to be reduced to three primary forms, viz., EXOGENS, or those which have their woody system separated from the cellular and arranged in concentric zones; ENDOGENS, in which the woody and cellular systems are mixed together in a confused mass; and ACROGENS, which consist of a cylinder growing at its point only, and never augmenting in thickness after it once is formed."*

The following table, presenting a comprehensive view of the classification of plants, is taken from Baron Cuvier's work:—

"The VEGETABLE KINGDOM containing living beings with roots, without sensation, or voluntary motion:—

DIVISIONS.	CLASSES.
1. A-COTYLEDONS. Agamons, or rather cryptogamous plants, without stamens or pistils.	1. Aphyllæ 2. Foliaceæ
2. MONO-COTYLEDONS. Plants having the embryo with only one cotyledon, perianth simple, consisting of a calyx only; floral organs, generally three, or multiples of three; nerves of the leaves generally longitudinal; stem composed of cellular tissue, with scattered vascular fascionti.	1. Hypogynia 2. Perigynia 3. Epigynia
3. DI-COTYLEDONS. Plants, having their embryo with two cotyledons, excepting the coniferæ, where are often from three to ten verticillate cotyledons; all of the parts of the stem disposed in concentric layers; flower generally with a calyx and corolla, the parts of which are usually five, or some multiple of five; nerves of the leaves generally ramified."	1. Monochlamydeæ 2. Dichlamydeæ *a* Corollifloræ *b* Calcyfloræ *c* Thalamifloræ.†

The author of the *Sacred History* gives the following explanation of the motives of the divisions which exist in the *Natural System* of Botany:—

"The seed contains the embryo plant in the little corculum, which all, on being carefully opened, display. It is familiarly called the heart of the walnut, the little figure at the one end of all nuts and kernels. Vessels extend from this to the substance in which it lies, which has received the name of cotyledon. If this be single, as in the grasses and corn, it is MONOCOTYLEDONOUS; if, as in the larger herbs and trees, it consists of two lobes, they are called DICOTYLEDONS; and, if no such are discernible at all,

* Library of Useful Knowledge, p. 14.
† Edinburgh Journal of Natural History, p. 18.

they are termed Acotyledonous plants, which in some, and, perhaps, in most countries are the most numerous."

These quotations will be sufficient to convince any one that all known plants—and the number known and classed, recent and fossil, is very great—may either be referred to, or distinguished by comparison with some one of the *three classes* enumerated. In order to be able to do this when requisite, the next step will be to unfold more minutely their distinguishing characteristics. I begin with the Dicotyledons.*

In the *hundred and seventeenth* Theorem it is stated, "*That the Dicotyledonous class is distinguished by the existence of pith in the centre of the stem, by increasing exogenously, and by medullary rays proceeding from the centre of the circumference of their woody parts. That the seeds are furnished with two fleshy lobes called cotyledons attached to a rudiamentary germ concealed between them.*"

This definition shows that the plants composing the *Dicotyledonous* class possess numerous peculiarities of construction, by which they can be distinguished from the other two. But the characteristics to which I am more desirous to direct the attention for the present, are their *manner of seeding*, and the *construction of their stems*, for on those two points will hang the burden of the proof required to substantiate my future argument. Therefore, with this design, as well as with that of preparing the way for certain explanations which are to follow, I beg the reader's attention while a brief but instructive detail of the *reproductive* organs of the *phanogamous* plants in general is given.

The writer on Botany in the Library of Useful Knowledge, already alluded to, says—

"All the parts hitherto treated of belong to what are called the *organs of nutrition*, or of *vegetation*. . . . . . Everything which is developed subsequently to the leaves belongs to the *organs of reproduction*, or of *fructification;* the sole office of which is to secure the perpetuation of species by seed, an action they are enabled to perform by the nutrient properties of the stem and leaves. . . . . .

"A perfect flower consists of three principal parts; namely, the *floral envelopes*, the *fructifying system*, and the *fertilizing system*. Of these, the two last are always present, either both together or in separate flowers; the first may be either present or absent, not being absolutely essential to a plant. The floral envelopes, generally, consist of two different parts, the *calyx* and the *corolla*. . . . . .

"There seems no means of defining the *Calyx* better than as the most exterior whorl of the floral envelopes; and, consequently, the name is so applied, whatever the colour, size, or other characters of the exterior whorl may be; and hence, if there is only one whorl, that one is the *calyx*. . . .

"The *Corolla*, although it is only to be known with certainty from the calyx by its being placed between that part and the stamens, is often, never-

* This, according to some botanists, is *Sub-Class* 1st of Class 1st, Vasculares, or Flowering Plants.

theless, the most conspicuous part of the plant, because the gay colours and the fragrant odours of flowers are generally resident in it. . . . . .

"The office of the floral envelopes is in part to act as a protection to the fertilizing and fructifying organs when they are young, and to guard them from sudden variations in temperature, being interposed between those parts and the atmosphere. . . . . .

"The *Fertilizing system*, called by many modern writers the *andræceum*, consists of organs which are technically named *stamens*, and usually consist of two parts, viz.—a slender white stalk, or *filament*, and a yellow or brown head, or *anther*, which is the essential part; the filament being of no more importance to the latter than the footstalk to the leaf.

"An accurate idea of the normal state of the filament and anther may be taken from the lily. In that plant the *filament* is a long, fleshy, awl-shaped, greenish-white body, the surface of which is furnished with stomates, and the centre with a bundle of vessels. On its point is placed the *anther*, which is a narrow reddish-brown body, having a deep furrow passing down its longer diameter, and being thus separated into two parallel lobes. The part that unites the lobes is a continuation of the filament, and is called the *connective*. Each lobe before it opens is marked in front with a shallow furrow, which passes from end to end of the lobe. In course of time the sides of the lobe contract and separate at the last-mentioned furrow, which consequently opens and allows a brownish-orange powder named *pollen* to fall out; the two sides of the lobe when they thus separate are called *valves*, and the furrow itself the *suture* or *line of dehiscence*. . . . . . This may be considered typical of all filaments, and of all anthers. Both these parts are, however, subject to numerous important modifications. . . . . .

"The *Pollen*, which looks like very fine dust, is the most curious and varied part of vegetation. It consists of a multitude of little grains, whose figure, generally uniform in the same species, have some hundred modifications of form in different species, and vary in size from the 1-30th to the 1-240th of a line in diameter. . . . . . The matter which is ejected from the pollen appears, under a microscope of low power, to be merely a turbid fluid, denser than the water into which it is discharged; upon magnifying glasses of sufficient power being applied, it is found to consist of oblong particles about the 1-5000th part of an inch in diameter, and spheroidal molecules varying in size from the 1-15,000th to the 1-25,000th of an inch in diameter, according to the computation of M. Dolland. It is generally believed that these particles are the rudiments of embryos, and that the effect of fertilization is to convey one of them into the ovule.

"The *Fructifying system*, or *gynæceum*, is the part round which all the other parts are arranged; it is generally the *pistil*, and consists of certain component parts called *carpels*, which are either distinct from each other, or all grown together into one body; or, if the pistil consists of but one carpel, then the terms pistil and carpel have the same meaning.

"A carpel consists of *ovary* and *ovules*, *style*, and *stigma*. The *ovary* is the lower portion, which is hollow, and within which is a double line corresponding with an external suture, and called the *placenta*. The ovary tapers upwards into a slender horn or thread, called the *style*, on the point of which there is a humid space, destitute of cuticle, which is the *stigma*. Of these parts the *ovary* and *stigma* are present in all *carpels*, but the style is not absolutely essential.

"To the naked eye the *Ovule* is an oval grain of a mother-of-pearl colour, and seems merely a bag of gelatinous matter; but in reality it is an organ whose structure is by no means so simple. It consists of a central part, called the *nucleus*, over which are placed one, two, three, or four membranes, called from their position the *primine, secundine, tercine,* and *quartine;* the *primine* being the most external. . . . . .

"The *Fruit* of a plant is the fertilized *ovary* arrived at maturity, and consequently both organs must have the same structure in all their more essential points; for the plan upon which the ovary is to be constructed is finally determined at the period when fertilization takes place. . . . . .

"We proceed next to some observations upon the normal condition of the fruit. . . . . . Some descriptions of fruit are always closed up to the latest hour of their existence, as the cocoa-nut; others have the property of bursting into separate pieces or *valves* when ripe. . . . . .

"In order to avoid circumlocution, the numerous varieties which occur among fruits have been classified by botanists, and names given to the most important of their modifications, such as *the Follicle, the Legume, the Achenium, the Cariopsis, the Utricle, the Nut, the Key, the Drupe, the Berry, the Gourd, the Pome, the Siliqua, and, finally, the Capsule.*

"Besides which there are several fruits not produced by single flowers, but which are formed by the adhesion of a considerable number of flowers into a single mass. Such is the fircone, the pineapple, and the mulberry, varieties of the strobilus.

"The *Seed.* While changes are coming over the pistil, the ovules are also undergoing a metamorphosis still more interesting and important. No sooner has the mysterious influence of the pollen been introduced into the ovule, than its foramen closes up; its integuments extend and harden, the pulpy substance within them consolidates, and in the midst of the latter, within the kernel, close to the foramen, there appears a minute, yellowish, opaque speck, which gradually enlarges and projects forwards into the centre of the kernel, absorbing the fluid that surrounds it, and, by degrees, assuming the appearance of an organised body, which it ultimately becomes, in the form of an *embryo* plant.

"The embryo is originally formed in the midst of the pulpy substance of the kernel, and is nourished by it during its growth. This pulpy matter bears apparently much the same relation to the embryo plant as the white of an egg to an embryo bird; and hence it has obtained the name of *albumen.* Usually this substance is so wholly absorbed by the embryo that no trace of it is left behind."

Professor Henslow says—

"Beans, peas, almonds, the kernel of our stone fruits, &c., afford us familiar examples of the structure of the seeds of *dicotyledonous* plants. When the outer skin is removed, we find that they are composed of two large fleshy lobes termed 'cotyledons,' which are attached to a small rudimentary germ almost entirely concealed between them. The entire mass forms the 'embryo,' and the skin which invested it the 'seed cover.'"*

Having thus become minutely acquainted with the Seeding processes of Dicotyledonous plants, we shall, from the same authorities,

* Botany, in Cab. Cyc.

briefly describe how their stems are formed, and the manner of their increase, whence they derive the name of "*exogens.*"

"The central part, or axis, of a plant," says the distinguished botanist I have been quoting from, "to which the leaves and flowers are attached, is technically called the *caudex*, to which the English word *trunk* seems equivalent, notwithstanding its being generally applied to the thick bole of a tree.

"It consists of two portions; the ascending trunk, or *stem*, and the descending trunk, or *root*. Between these there is no absolute separation, each being an extension of the other in an opposite direction; the ascending trunk, or stem, having from its earliest existence an invincible tendency to grow upwards into the air and light, the descending trunk, or root, an equally irresistible determination to the earth, away from the light. . . . . .

"In their internal structure roots and stems are nearly alike, except that the former are rarely hollow, although many stems are; and that in the plants called *exogens*, which have a pith in the centre of their stem, the root has no pith. . . . . . In most plants the stem is solid: in grasses and umbelliferous plants it is hollow."

Some explanation of the internal structure of the stems being requisite, I shall next enter into a brief examination of their component parts.

"A stem formed upon the *exogenous* plan, when cut through transversely, exhibits a central *pith*, surrounded by one or more circles of *wood*, on the outside of which is a ring of *bark*, which is connected with the pith by a number of lines passing through the wood called *medullary processes*. . . . . Let us briefly examine the structure of the various parts that make an *exogenous* stem.

"The *Pith* is a spongy column which extends from the collar, where it usually ceases, to the extremities of the branches. When young it is succulent; when old it becomes dry. . . . . It is united with the *medullary* rays or plates, or *processes*, as they are more correctly called, by an infinite multitude of points arising from over all its surface. . . . . .

"The *Medullary Processes* which thus arise from the pith, of which in fact they are mere extensions, pass straight into the bark, cutting the intervening wood into a number of wedges, the broad end of which is next the outside of the stem. . . . . . Their component parts are placed with their longer diameter perpendicular to the bark; a position which is the most favourable to perform their functions. . . . . .

"The *Bark* consists of an external layer of a spongy substance which is usually green, and of an interior layer of fibrous matter which touches the wood. Of these layers the external is called the cortical integument, and the interior the *liber*. Every year an addition of new *liber* is made, in the form of a concentric zone within that of the preceding year. . . . . . It is through the bark exclusively that the returning fluid of a plant descends to the root; and it is in this part that many secretions are chiefly stored up. . . .

"The nature of the *wood* will be best understood by examining the structure of a single zone, and considering all the other zones subsequently formed to be merely repetitions of it. Next the pith is placed what is called the *medullary sheath*, which is a stratum of air vessels forming a sort of casing to the pith, but interrupted perpetually by the medullary processes

which pass through it. On the outside of the medullary sheath is a mixture of large vessels and fibrous matter, the former predominating; and on the outside of all, finishing the concentric zone, is a deep mass of fibrous matter, with a number of small vessels intermixed; in all the other zones exactly the same structure is repeated as long as the plant continues to grow; so that the trunk of the largest exogenous tree is a mere repetition of woody or cortical zones; the youngest of the latter being formed within-side the older, and the youngest of the former outside the older. . . . . . In some plants scarcely any vessels are to be distinguished among the fibrous matter of the wood, or there is but little apparent distinction between the different zones; but, in the main, the structure just described is that of *exogens* in general."*

Whatever degree of attention may have been given to the perusal of these leading characteristics of the plants composing the class occasionally termed EXOGENÆ, but more usually DICOTYLEDONS, will have been sufficient to convince any one that none of them could have existed during *the long, but indefinite period when the earth was without rotation, enveloped in darkness, and circumbounded by water.* They all require light, atmospheric air, and dry land;† not only for their perfection and reproduction, *but even for their very existence.* It may not, besides, be inopportune to observe, with more particular reference to the woody fibre of their exogenous stems, that as "every *year* an addition of new *liber* in the form of a concentric zone beyond that of the previous one is made to them," *each zone being the material index of the vicissitudes of summer and winter, marked with undeviating precision by the finger of time within the stems of the Dicotyledons,* these zones could *not* have been formed *before* the seasons were instituted by the lighting up of the sun, by the same Omnipotent Being who chose to reserve this central orb in darkness for many ages. Thus we acquire, by every new object of investigation, additional and concurring testimony of the truth of the assertion that such was then the state of the solar system.

It will also have been observed, that by whatever denomination the plants composing the *Dictoyledonous* class may be called, they all "produce fruit whose seed is in itself;" whether they are designated as the *legume*, or that implied by it, the bean, or the *pea*; or by *drupe, nut, glans, capsule, berry,* or *pome,*‡ they are all alike—"fruit after his kind, whose seed is in itself upon the earth;" and, consequently, whether these are produced by a tree as majestic as the *oak,* or as diminutive as the *radiola millegrana,* they alike come under this clear and comprehensive classification. Indeed, there is no definition which, in so few words, can be made to group together, by one common characteristic, such an infinite number and so great a diversity of plants as those composing the *Dictoyledonous Class:*

* Library of Useful Knowledge, pp. 9—16. In order to restrict these quotations within due bounds I have been obliged to curtail them more than I otherwise would. Their perusal, in the original, would amply repay the reader.

† Theorems 118 and 120. ‡ 119th Theorem.

while the wonderful wisdom which selected the *fruit or seeding processes* as the one grand common feature, becomes the more apparent when it is remembered *that all the other parts of the plant are subservient to this one essential object—the means of perpetuating itself by reproduction;* and that, however diversified the intermediate processes may be which lead to this, they all meet, as it were, by myriads of distinct approaches at this common comprehensive resting-place—"*Fruit after his kind whose seed is in itself.*"

It is scarcely necessary to remind the reader that the *Dicotyledons* constitute a great proportion of the plants of the earth, that they are much diversified in different countries, some being more common to one part than to others; and, what is still more remarkable, it appears pretty well established by the concurring testimony and the researches of botanists, that there are plants of this class, as well as of the *Monocotyledonous* kind, *peculiar* almost exclusively to certain localities and detached islands; showing that there have been distinct foci of creation in the vegetable kingdom: a fact very essential to be borne in mind, and which I beg may be noticed, for I shall have occasion to recur to it in another place.

As it may be conducive alike to unity of design and to the attainment of a more perfect knowledge of this great division of the vegetable kingdom, to enumerate the several *orders* which are comprised in it, I do so, selecting for that purpose the classification given by Sir William Jackson Hooker in the *Flora Scotica;* in which he commences with the imperfect, and goes up to the *Vasculares*, or *Flowering Plants*.

Accordingly, *Class* III. are DICOTYLEDONS, and are thus described:

"*Embryo*, with two or more *cotyledons*, *plumule* in the centre of their point of junction; the inferior end of the *embryo* itself elongated into a *radicle*, and not containing any secondary *radicles* in its substance. *Stem* increasing by external layers or additions, with an evident distinction between bark and wood. *Leaves* usually varied, rarely nerved."

The following numerous Natural Orders are classified under this division, namely:—

1. Coniferæ	14. Primulaceæ	27. Oleineæ
2. Corylaceæ	15. Lentibulariæ	28. Ericeæ
3. Salicinæ	16. Verbenaceæ	29. Vaccineæ
4. Ulmaceæ	17. Melampyraceæ	30. Monotropeæ
5. Urticeæ	18. Labiatæ	31. Campanulaceæ
6. Aristolochiæ	19. Scrophularinæ	32. Compositæ
7. Euphorbiaceæ	20. Orobancheæ	33. Dipsaceæ
8. Rosedaceæ	21. Solaneæ	34. Valerianeæ
9. Thymeleæ	22. Boragineæ	35. Rubiaceæ
10. Polygoneæ	23. Convolvulaceæ	36. Caprifoliaceæ
11. Clenopodeæ	24. Polemoniaceæ	37. Loranthеæ
12. Plantagineæ	25. Gentianeæ	38. Umbellifera
13. Plumbagineæ	26. Apocineæ	39. Saxifrageæ

40. Grossulariæ	51. Aceraceæ	61. Droseraceæ
41. Halorageæ	52. Tiliaceæ	62. Cisteæ
42. Onagrariæ	53. Malvaceæ	63. Violaceæ
43. Cucarbitaceæ	54. Geraniaceæ	64. Polygaleæ
44. Salicariæ	55. Oxalideæ	65. Cruciferæ
45. Illecebreæ	56. Balsamineæ	66. Fumarieæ
46. Rosaceæ	57. Lineæ	67. Papaveraceæ
47. Leguminoseæ	58. Caryophylleæ	68. Nymphyaceæ
48. Rhamneæ	59. Sempervivæ	69. Berberideæ
49. Celesstrineæ	60. Portulaceæ	70. Ranunculaceæ.*
50. Hypericinæ		

Before concluding this part of the subject, it may be well to bring before the mind the perfect conformity in the condition of the earth at the period when it is recorded that the objects forming this class of the Vegetable Kingdom, which require light, atmospheric air, and dry land for their existence and perfection were introduced. The inspired historian informs us they were willed into being on the latter part of the third day, that is, after the primary light, the atmosphere, and dry land had been formed—or precisely at the juncture most appropriate for their introduction.†

I must now proceed to display the characteristics which distinguish the MONOCOTYLEDONOUS class,‡ the second division of plants according to the natural system. I shall begin by recapitulating the definition given of them in the *hundred and sixteenth* Theorem: "*That in the Monocotyledons—consisting of several orders—there is no distinction between the pith, the wood, and the bark, but their stems consist, generally, of a cylindrical, though sometimes of an angulated mass of cellular tissue, in which are bundles of vascular tissue, without medullary rays. That they are called Endogenæ, from the newly-formed material developing itself towards the innermost part of their stems. That an albuminous mass forms the main bulk of most of the monocotyledonous seeds, having the embryo placed within it; the general character of these seeds being that of a cylindrical body tapering towards the*

* Flora Scotica, pp. 194, 297. I consider it almost superfluous to point out, that as this flora is confined solely to Scotland, there must, of course, be a great many more Natural orders, both in the Monocotyledonous and Dicotyledonous divisions in other countries, besides those which are detailed by Dr. Hooker. It will, however, be seen in the sequel, that my object shall have been fully attained should a conception be acquired of the kind of plants which usually are classed in those two divisions, especially in the *first*, and by establishing determinately the Natural orders which belong to the *Acotyledonous* division, on which the future argument will materially depend. Fortunately types of all those in this last division which are known in any country are likewise found in Scotland—one of the chief motives for my having selected the *Flora Scotica* as a text book.

† Theorems 118 and 120. MM. Lindley and Hutton, when reasoning respecting the probable state of Melville Island during the ancient epoch, and showing the impossibility of such plants as are found in those latitudes growing there now for want of light, says, "For light is an agent without which no growing plants can exist, at the present day, for a single week, even in a low temperature, without suffering serious injury."

‡ By some botanists this is called *Sub-class* second of CLASS first, VASCULARES; or FLOWERING PLANTS.

extremities, from one of which, in due time, protrudes the radicle, and from the other arises a single, conical, and almost solid cotyledon."

In order to acquire a somewhat more intimate knowledge of the structure, properties, and habitudes of the numerous and delicate plants composing this group, it will be necessary to go into a few details to enable us hereafter to judge of the correctness of the conclusions deduced from them. First of the SEEDS.

"The general structure of the seeds of the Monocotyledonous class of plants," says Professor Henslow, "may be exemplified by the examination of a grain of Indian corn, wheat, &c.; or of a seed of an onion, lily, &c. An albuminous mass forms the main bulk of most of these seeds, and the embryo is placed within it towards the centre, or one side. The embryo is not so distinctly developed in the seeds of this class as in those of the dicotyledons; and its several parts cannot always be readily recognized before germination has commenced. Its general character is that of a cylindrical body, tapering more or less at the extremities, from one of which protrudes the radicle, and from the other arises a single, conical, and almost solid cotyledon. This elongates, and is ultimately pierced by a leaf, rolled into a conical form, and which was at first completely invested by the cotyledon."*

In the *Library of Useful Knowledge* it is stated that—

"All the foregoing modifications are easily intelligible upon reference to the typical form of the embryo; but there are others called *Monocotyledonous*, because they have only one cotyledon; in which the analogy between them and the supposed type is at first sight not apparent. Take, for instance, the embryo of a cocoa-nut; it is a taper, fleshy body, somewhat club-shaped at one end, and abruptly blunted at the other; no trace of cotyledon, plumule, or radicle is externally discoverable. If, however, it is divided with a thin and sharp knife from top to bottom into two equal parts, it will be found that near the blunt end there is an internal conical tumour directed upwards; this is ascertained by the germination of a cocoa-nut to be the young *plumule;* and this being known, it follows that the abruptly blunted end of this embryo is the radicle, and the other the cotyledon; hence it derives its name of *Monocotyledon.*"†

"*Endogenous* stems apparently differ very much from exogens, for they have neither pith, nor medullary processes, nor bark, nor wood, properly so called; but consist of a confused mass of bundles of woody substance lying in the middle of a spongy matter. In the palm we find an external cortical integument without liber; the bundles of woody matter so arranged as to be much more numerous and compact at the circumference than towards the centre. In the cane, which is another kind of palm, the woody bundles are distributed equally throughout the whole substance. In the asparagus, the aloe, and other soft-stemmed species, the woody bundles are not only equally distributed, but are so soft as to be scarcely recognized for the same thing as the hard fibres of a palm stem. Now, if we compare a stem of this sort with that of an exogen, we are, at first sight, unable to discover any analogy between them; but upon a more careful inspection it will be discovered that the principal organic difference consists in the woody matter of exogens being arranged in wedge-shaped parcels plunged into the spongy substance

* Botany, Cab. Cyc. † Library of Useful Knowledge, p. 56.

of the stem, and disposed in annual zones; while in the endogens the woody matter is neither collected into wedge-shaped parcels, nor arranged in annual concentric zones, but is broken up into fibrous bundles plunged without order into the spongy mass. . . . . . Another, and a more remarkable deviation from the general structure of endogens, is met with in grasses, the stems of which are generally hollow between the nodes where the sides are connected by transverse partitions; but the arrangement of matter in the solid shell being entirely that of palms, grasses cannot be considered to offer an exception to the law of endogenous structure."*

In working out the problem which I am so desirous to solve, I shall next briefly enquire what ORDERS of plants are grouped together under the denomination of MONOCOTYLEDONS or ENDOGENS; and whether they are of the description which are commonly called "*herbs*." Professor Henslow has asserted as an axiom "That the proportion of *Dicotyledons* to *Monocotyledons*, and of woody species to the herbaceous *increases* as we approach to the equator:" consequently, it is only necessary to reverse the axiom, to be made aware, that a northerly region will more greatly abound with *Monocotyledons;* and, applying this to practice, I shall appeal to the *Flora Scotica* as the most apposite text book for the purpose of enquiring whether MONOCOTYLEDONS may be considered HERBS. The following orders and their characteristics are taken from the work in question:

CLASS II. MONOCOTYLEDONS.

ORDER I. *Gramineæ.*—*Stems* fistulose, generally simple, and herbaceous, sometimes branched, rarely shrubby.

II. *Cyperaceæ.*—*Stems* slender or triangular; sometimes with an indefinite number of angles, usually without joints, sometimes jointed and branched.

III. *Restiaceæ.*—*Herbs,* or under shrubs.

IV. *Junceæ.*—In conspicuous herbs with small flowers, which are often brown, rarely petaloid.

V. *Butomeæ.*—Not particularised; but *Butomus* is an herbaceous plant.

VI. *Melanthaceæ.*—Not particularised; yet *Tofieldia,* which is one of the genera of Melanthaceæ, is described as 'scarce a span high.' (p. 14).

VII. *Asparageæ.*—Not particularised; but *Asparagus, Ruscus, Convallaria,* and *Paris,* are all herbaceous.

VIII. *Asphodeleæ.*—Not particularised; but *Ornithogalum, Scilla, Hyacinthus,* and *Allium,* which are of it, are decidedly herbaceous.

IX. *Liliaceæ.*—Not particularised; although *Tulipa,* which is in it, is herbaceous.

X. *Amaryllideæ.*—Not particularised; yet *Narcissus,* and *Gelanthus* are both herbaceous.

XI. *Irideæ.*—*Herbs,* rarely under shrubs.

XII. *Alismaceæ.*—Aquatics.

XIII. *Hydrocharideæ.*—Also aquatics.

Library of Useful Knowledge, pp. 17, 18.

ORDER XIV. *Orchideæ.*—Stem simple; rarely divided, leafy or sheathed.
XV. *Aroideæ.*—Herbs or under-shrubs.
XVI. *Juncagineæ.*—*Rigid herbs* with narrow radicle leaves.
XVII. *Fluviales.*—*Floating herbs,* with very vascular *leaves* and *stems.*

In describing generally "The Organization of the Stems" of this class, Professor Henslow says—

"In *Monocotyledons* there is no distinction between the pith, wood, and bark; but their stems consist of a cylindrical mass of cellular tissue, through which bundles of vascular tissue are distributed in a scattered manner. Every fresh development of new matter is carried towards the centre of the stem, and, as the stem elongates, the outer parts become more and more solidified, whilst the inner remain soft. These stems possess no traces of medullary rays. The plants of this class are termed '*Endogenæ,*' from the circumstance of the newly-formed materials being always developed towards the innermost part of their stems. A piece of cane is a familiar example for illustrating this structure; but we have no woody plants in our climate belonging to this class; and very few even which possess herbaceous stems, if we except the hollow culms of the grasses, where the development of the materials towards the centre is not sufficiently rapid to keep pace with the elongation of the stem, and the tissue is in consequence ruptured."*

These investigations, conducted in so detailed a manner, of the seeding processes, the construction of the stem, the formation of the leaves, and the designation as *herbs* of the second natural division of the vegetable kingdom, all concur in proving that, when compared, they agree in every possible point of view, with their simple but comprehensive classification in Genesis, so often referred to—"*the herb yielding seed after his kind upon the earth.*" They come up completely to, but do not exceed those standard characteristics. They are herbs bearing seed; but are not trees bearing fruit with seed in itself. To produce seed they require to flower, and although some are aquatic, yet they all flower in the open air, and require sun-light to enable them to perform their various functions: consequently they stand in the same relative position with respect to the darkness and circumfluent ocean which enveloped the primitive earth, as the *Dicotyledons.* Like them, they could not have grown while the globe was in that condition; and, for the same reason, the period they are recorded as having been brought into existence—that is, after the light and the atmosphere had been formed, and the dry land separated from the waters—is peculiarly and convincingly appropriate.

Those two great and comprehensive classes—the DICOTYLEDONS and MONOCOTYLEDONS—must now be looked upon in another point of view, and one which leads to considerable intricacy and difficulty. *They seem, between them, to embrace the whole of the plants recorded to have been formed by the earth, in consequence of the powers conferred*

* Botany, in Cab. Cyc., pp. 34, 35.

upon it by the Almighty, on the latter part of the third day of the Mosaic week: the one referring especially to "herbs yielding seed;" the other comprehending all "fruit trees yielding fruit after his kind whose seed is in itself upon the earth;" and thus *they oblige us to look to the previous creative influences of the Divine will, for the origin of all plants which do not fulfil either of those two conditions.*

In working out the conclusions to which these remarkable and apparently embarrassing facts may lead, no opposing obstacles—though these, indeed, may be neither few nor easily overcome—must deter me, as this would imply less than due reverence for the Almighty. The evidence of the senses constrains us to admit that there were numberless varieties of plants in existence for ages before He chose to *record* the last act of creative influence with respect to the vegetable kingdom; and, therefore, shrinking from, or even being fearful to assume such a position, which is borne out by undeniable evidence, would be doing despite alike to the power and to the wisdom of the Creator. For if it be conceded that God did create those plants which produce seed, and those trees which bear fruit with seed in itself, it would be quite inconsistent to deny his having previously willed into existence those other descriptions of plants required for the progressive perfection of his work, when "in the beginning He created the heaven and the earth," although we have not been expressly told when or how they were brought forth, during the world's dark and submerged condition. Our senses convince us, nevertheless, *that they then existed;* reason and analogy point out their uses and their habitudes; while Revelation leaves not the semblance of a motive for either doubting their existence, or for attributing their creation to any other being.

With this explanation, and begging it may be borne in mind that the chief difficulty will arise from that which is experienced in classifying the objects of research, in consequence of their imperfect nature, let us proceed to acquire a knowledge of the Third, or remaining division of the Plants known by the denomination of Acotyledons. Before commencing this, it may be well to observe, that a material difference exists between the more perfect tribes of the *Acotyledons*, called *Ductulosæ*, which are reproduced by flowerless sporules (substitutes for seeds), although possessing neither radicle nor plumule—such as those of ferns, mosses, marchantia, &c., and the still less perfect and more simple forms of the *cryptogamia*, termed *cellulares*, among which are *fungi*, *lichens*, and *algæ*, whose manner of reproduction is involved in obscurity and uncertainty;* while it is also to be remarked, that the lower we proceed on the descending scale, the less dependent these plants seem to be on the influence of light, and the more attached to dampness and moisture, until the *Algæ* is reached, an *order* whose natural element is water.†

* See this difference stated in a propositional form in the 115th Theorem.

† Popular History of British Algæ, by the Rev. Dr. Landsborough, 1849.

According to the *hundred and fourteenth* Theorem, which treats of the *cryptogamous* plants, they are distinguished as follows:—*The Acotyledonous or Cryptogamous Class includes an extensive series of plants, grouped under several Orders, differing considerably in many particulars, but the whole agreeing in the important circumstance of never bearing flowers. That, having no flowers, they produce no true seeds, but, in lieu thereof, the higher tribes are furnished with minute granular bodies, capable of becoming distinct plants, called sporules; not separable into distinct parts with radicle, plumule, and cotyledons, like the seeds of phanogamous plants. That these sporules possess the power of producing from any part, either stem or root, as circumstances may require, while it is quite otherwise with true seeds. That acotyledonous plants increase acrogenously.*

I shall commence the evidences in support of this *Theorem* by quotations from a work which recommends itself alike by its intrinsic merits, and by the care and assiduity bestowed by its author on the *Cryptogamic* class of plants, in a field of labour where they peculiarly abound—I allude to the *Flora Scotica*—while the evidences to be adduced will likewise prove, that the *Tripartite* division, pointed out by the internal structure and general formation of the stems, leaves, and floral envelopes, is not an arbitrary, but a natural classification; for when the divisions into which the various objects of the Vegetable Kingdom arrange themselves, when their *seed lobes and sporules, or modes of germination,* are made the criterion of separation, it will at once, and with satisfaction, be observed, that they are in perfect unison with that which the stems and leaves likewise point out:—

"PART II.

"CLASS I. ACOTYLEDONS. *Jussieu.*

"(Cryptogamia, *Linnæus.* Acotyledons, and part of Monocotyledons. Ferns of *De Candolle* and *Brown.* Agamæ and Exembryonatæ, *Richards.*)

"*Fruit*, or organs of reproduction without any *Cotyledon.*

"*Vegetation.* In all, with the exception of the Ferns, the structure seems to be entirely cellular, and hence the term '*Cellulares,*' applied to them by De Candolle, in opposition to '*Vasculares,*' or those plants which, in addition to the cellular structure, have tubular vessels, as in the Cotyledonous plants and the *Ferns;* on which account De Candolle and Brown have removed these into the 2nd class, or Monocotyledons.

"This class contains the following distinct Natural ORDERS:—

"I. Fungi. II. Lichens. III. Algæ. IV. Characeæ. V. Hepaticæ. VI. Musci. VII. Filicis. VIII. Lycopodineæ. IX. Marsileaceæ. X. Equisetaceæ."*

The botanical writer, from whose work I have already so copiously extracted, says—

"The foregoing observations have carried us, somewhat superficially, it

* Flora Scotica, part ii. p. 3.

must be confessed, but at the same time consecutively, through all the principal circumstances which occur in the life of a *perfect* plant.

"All that relates to *imperfect* plants, or those which are increased by simple division of their own substance, and not by seeds, is equally explicable by the same rules, with the single exception of their *reproduction*. Upon this head it is necessary that we should offer a few special remarks.

"It must be obvious, upon consideration, that plants in which there exists neither stamen nor pistils, and in which there consequently cannot take place any of those phenomena we have lately been examining, must also be destitute of *seeds;* for a seed is nothing but a sac of mucous matter in a particular state of organization into which either the germ of a new individual has been conveyed, or wherein its existence has been produced by some unknown action of pollen.

"That nature has not, however, neglected the means of propagating the lower tribes of plants is plain from their great abundance in favourable situations; and, upon examination, we find they have what are called *sporules* or *spores,* which are lodged in parts that may be considered analogous in their function to carpels, although they have not only no resemblance in structure to those parts in flowering plants, but also very little among each other; the spore cases being sometimes elaborate pieces of organization, as in ferns and mosses, and sometimes mere simple tubes buried in the substance of the plant, as in lichens, fungi, &c.

"In regard to these plants, then, no difference exists between seeds and sporules, except as to the origin, organization, and mode of development of the latter. Instead of having their centre divided into plumule and radicle, to which one or two cotyledons are attached, they are mere homogeneous masses of cellular substance; and instead of uniformly growing from two constant points of their substance, from one upwards and from the other downwards, *they are capable of sprouting into root or stem, indifferently from any point of their surface;* the nature of the part which the spores produce depending, not upon pre-existing organization, but upon accidental circumstances. When they begin to grow, that portion of the surface which is exposed to light extends into a stem, and that which is turned to darkness and humidity becomes root. . . . . .

"Let us not, however, be led astray by specious theories concerning bodies so far beyond the cognizance of our senses; but, in the absence of demonstrative evidence to the contrary, let us believe the great Author of Nature to be consistent with himself in all His works, and to have taken care to enable the most humble sea-weed to be multiplied by some means as certain and unchangeable as is provided for the most stately lord of the forest. We may rest assured, for all philosophy, and all observation, and all reason prove it, that there is no such thing in nature as blind chance, but that all things have been carefully and wisely designed with reference to the particular circumstances under which they exist."*

With respect to the reproductive organs of *Cryptogamous* plants, Sir Wm. Jackson Hooker expresses himself in the following impressive words, to which I beg particular attention:—

"The more intimately we become acquainted with the reproductive organs of the *Acotyledonous* or *Cryptogamic* plants, the more apparent is it, in

* Botany, in Library of Useful Knowledge, pp. 117—119.

my opinion, that there are no sexes as in the phanogamous plants, no stamens, and no pistils, nor anything analogous to them; consequently, no true *seed*, which can only be produced through their co-operation. The structure of the *seeds* themselves (more properly *sporules*), tends greatly to confirm such an opinion; there being in reality no distinction into *cotyledon, radicle*, or *plumule*; in short, no embryo, any more than is in the little bulbs seen upon the stalks of the onion tribe, and on the *polygonum, viviparum*, &c., which yet equally produce perfect plants. *A sporule has alike the power of producing from every part, either stem or root, as circumstances may require; but it is quite otherwise with the true seed.*"*

"*Acotyledons*," says Professor Henslow, "include an extensive series of plants, grouped under several orders, which differ considerably in many particulars. The whole agree, however, in the important circumstance of never bearing flowers like those of the two former classes: hence they are termed '*cryptogamic*,' in contradistinction to '*phanogamic*,' which is applied to all flowering species. Having no flowers they produce no true seeds; but in lieu of them are furnished with what certainly bears a considerable resemblance to seed, viz.: small minute granular bodies capable of becoming distinct plants. The manner in which these 'sporules,' as they are termed, are produced, is very various in the different orders of this class, but forms no part of our present enquiry. They are also variously shaped, but generally spherical or spheroidal, and are not separable into distinct parts with radicle and cotyledon, like the seeds of phanogamous plants. In germinating, the sporules are developed by an increase of cellular tissue, which appears in the form of rounded masses and filamentous chords. Among the higher tribes roots are afterwards produced, and a part which is more or less elevated above the soil is the representative both of the stem and leaves of phanogamous plants combined. In the lower tribes, however, there is seldom any separation of parts into distinct organs, but the functions of nutrition are carried on in an obscure manner by the general mass.

"*Acrogens*, as the cryptogamia are called, are totally different in the organization of their stems from either the *Exogens* or *Endogens*. In ferns, which are most remarkable both for their size and singularity of structure, the stem is a cylinder usually hollow; if solid, having the centre filled with spongy substance, destitute of bark, with neither woody bundles nor woody wedges interposed among the general substance of the stem. The shell of this cylinder, which answers to the woody part of other plants, is composed of excessively hard plates, folded upon themselves in such a manner that a section of them represents a number of sinuous lines doubling about among spongy matter. These never increase in thickness, number, or quantity after being once formed; but they seem as if they were, as in all probability they are, mere prolongations of the woody matter lying inside the footstalks of the leaves; whereas *exogens* increase by addition to the outside of their wood, and *endogens* by addition to the inside of their stem; whence their respective names have been formed. *Acrogens* seem to have little or no power of increase in diameter, but simply to lengthen by continual extension of their points; their name has been contrived from this circumstance.

"To these principal variations of the mode of growth in the stems of plants, should, perhaps, be added a fourth form, of which little notice has hitherto been taken by botanists. This, which may be called the *centrifugal*,

* Flora Scotica, part ii. p. 3.

occurs in fungi, lichens, and the lower orders of plants; and consists of a fleshy or spongy mass, or of filamentous processes radiating from a common centre.

"In many respects this is the same as the *Acrogenous*, of which, indeed, it may be considered a mere variety; for its ramifications do not increase much in thickness after they once are formed; it nevertheless deserves to be specially explained. In an obscure plant called Marchantia, Mirbel found that a little thin green plate was first formed by the action of the reproductive grains or seedlets; and that it was from the edges of this plate, when once fully formed, that all the succeeding expansions took place, as from a common centre, but always upon the same plane; so that in such plants the central part is the oldest, and the circumference the youngest. This is very apparent in lichens, which, when very large, are always dead in the centre, while they continue to go on growing from every part of their margin. These appearances are external indications of the centrifugal growth of the subterranean stems of certain agarics, which originally spring from a common point, continually spreading outwards upon the same plane, the central or first-formed parts perishing as the circumferential or latest-formed parts develope."*

* Botany, in Library of Useful Knowledge, pp. 9—19.

SECTION II.

THE VEGETABLE ORGANISMS OF THE NON-ROTATORY PERIOD.

CHAPTER V.

Summary application of what has been established in the foregoing Chapter. DICOTYLEDONS comprehend all plants "bearing fruit whose seed is in itself upon the earth." MONOCOTYLEDONS embrace "the herbs yielding seed." But the Vegetable Kingdom being examined into, a third description of plants is discovered, bearing neither flowers, fruits, nor seeds, called ACOTYLEDONS, and these are supposed to have been created during the non-rotatory period. Lists of Fossil Plants, given in corroboration, from the chalk formation downwards, and from two distinct sources—from Geological writers, and from the works of Fossil Botanists. General observation confirmatory of these lists. Brief explanations respecting vestiges of flowering plants occasionally included in the foregoing lists. Review of the progress made thus far. Adaptation of the imperfect, flowerless plants to the state of the creation during the anti-rotatory period; and their capability of having grown and propagated in a submerged condition confirmed, by contrast with the incapability of flowering plants to have existed without either light, atmosphere, or dry land.

THE copious explanations and botanical descriptions, taken from accomplished writers on that interesting division of natural objects, which have been given in the preceding chapter, will have sufficiently prepared the mind for the application which alone induced me to enter so fully into them. The position I shall endeavour, with their aid, to establish is—That considering the *Dicotyledonous* Class of plants comprehends indiscriminately all those "*which bear fruit whose seed is in itself upon the earth;*" and the *Monocotyledonous* division, in like manner, includes all "*herbs which yield seed;*" and that these two, together, embrace all descriptions of vegetable objects willed into existence *during the Mosaic week;* and, considering it to be equally well known, by reason and observation, that there does exist another great division of the Vegetable Kingdom, differing from either of them, we are constrained to conclude, while I am prepared to prove, *that before the world revolved around its axis there did exist beneath its waters innumerable plants of great secreting powers, pertaining to, or very much resembling, the flowerless* ACOTYLEDONOUS *class of the present day, which, by means of their cryptogamic construction, and other peculiarities, were there enabled to exist, to propagate, and to acquire vast dimensions.*

As the only effectual corroboration of this view of the case (considering the epoch to which I allude), I have given in the Appendix*

* See Appendix D.

two distinct, but corresponding consolidated lists; one abstracted from M. de la Beche's manual of the fossil vegetable remains discovered in the several stratified masses, from the chalk down to the non-fossiliferous rocks of primary formation; and the other from Messrs. Lindley and Hutton's Fossil Flora, in which the objects are classed *botanically*, together with notes from other scientific writers on the same interesting subject. The well-established character of these authorities warrants the expectation, that perfect confidence will be placed in those lists and explanations; while the surprising conformity which they make manifest between the result of actual discoveries, and the *a priori* conclusions I have come to, by perfect dependence on Revelation on the one hand, and on scientific researches on the other, will, I earnestly trust, lead ultimately to the complete establishment of the truth.

The copious extracts and lists, which, even at the risk of being thought tiresomely profuse, I have given in the Appendix, will, it is hoped, be considered sufficient to prove the existence of vegetable remains in the older stratified masses, and fully to have exhibited their character; should, however, further evidence be wished, reference may be made to the geological works mentioned in the course of this Treatise, from which these extracts have been taken, where all required information will be found.

No explanation, beyond the notes and surmises mentioned in the course of these proofs, can be given for the apparent anomaly caused by the occasional presence of some *Monocotyledons*, and of a few *Dicotyledons*, amongst the fossil vegetable remains. Vestiges of each may have more recently sunk down into fissures and crevices, and there become fossil, appearing to belong to geological periods much more remote than those in which they grew; while I may with confidence avail myself of what Messrs. Lindley and Hutton and Professor Henslow assert, which forms the basis of the *hundred and twenty-seventh* Theorem,* respecting the difficulty of comparing the mutilated fossil vestiges with their recent analogues, and rely with composure on a more thorough examination for the elucidation of the difficulty; feeling thoroughly convinced that no *Monocotyledonous* or *Dicotyledonous* plant, properly so called, which required floral envelopes for the development of its seed, did, or could possibly have existed previous to the light, the atmospheric air, and the elevation of the dry land above the waters: while, as regards the perplexities attendant on the classification of *fossil* plants, to which Professor Henslow so clearly alludes in his work, they could not possibly be described in more clear or forcible language than that which has been employed by those botanists who, more than any others, have been inconvenienced by them.

"Unfortunately," say Messrs. Lindley and Hutton, in the Preface to their

* To which please refer.

great work, "Fossil Botany is beset with difficulties of a peculiar character; the materials that an enquirer has to work upon are not only disfigured by those accidents to which all fossil remains are exposed, but the parts found are those which in recent vegetation would be considered of the smallest degree of importance. There is, in most cases, an almost total want of that evidence by which a botanist is guided in the examination of recent specimens, and not only the *total destruction of the parts of fructification,* and of the internal organization of the stem, but what contributes more to the perplexity of the subject, a frequent separation of one part from another; of leaves from branches, of branches from trunk; and, if fructification be present, the separation of it even from the parts of the plant on which it grew, so that no man can tell how to collect the fragments that remain into a perfect whole; for, it must be remarked, that it is not in botany as in zoology, where a skilful anatomist has no difficulty in combining the scattered bones of a broken skeleton.

"In botany, on the contrary, the component parts of both foliage and fructification are often so much alike in outline, which is all that the fossil botanist can judge from, as to indicate almost nothing when separated from each other, and from the axis to which they appertain. It is only by the various combinations of these parts that the *genera* and *species* of plants are to be recognized, and it is precisely these combinations that in *fossils* are destroyed."*

Should any one be disposed hastily to conclude that these assertions ought to invalidate the *whole* of the evidence sought to be adduced by the findings and announcements of *Fossil Botanists;* labouring, as they do, under such disadvantages, and so much exposed to the possibility of giving a wrong decision when classing the petrified fragmental specimens which time and many casualties have spared for their inspection; I would beg to observe, that besides the circumstance of ferns and some allied cryptogamic plants being those whose remains have best resisted the lapse of ages, and are found most perfect and entire, the *negative* character of the proof which most corroborates my position enables me in this case, to avail myself, alike, of what exists and what does *not.* Guided by the announcements of Scripture, I did not expect that there should have been found either true "*seed of herbs,*" or true "*fruit of trees with seeds in them,*" although the discovery of reproductive processes of some kind or other was counted on. Consequently, the absence of the two former—the phanogamous means of propagation—so far from militating against my argument, has a tendency all the other way; and as such I adopt and recommend it to my readers.

Considering this a convenient resting-place, from whence to take a review of the ground which has been gone over in this and the previous chapter, which has unavoidably been much broken and uneven, I shall briefly recapitulate what has been done, not only in order to refresh the memory, but likewise, the more effectually to apply what has been acquired to what has yet to be accomplished.

* Fossil Botany, by Lindley and Hutton. See also p. xxvii. of same volume, and p. vi. of part i. of volume ii.

By an enquiry into the characteristics of the *first* great CLASS of plants, the *Dicotyledons* or *Exogenæ*, it was found that they corresponded so closely to the group mentioned in Scripture which "*bear fruit having seed in itself*," that they completely filled up that division of the Vegetable Kingdom. By a similar investigation into the nature and structure of the *second* class, called *Monocotyledons* or *Endogenæ*, it was discovered that, being "*herbs bearing seeds*" merely, they, in like manner, completed the group designated in Genesis "*the herb yielding seed.*" But as these two *classes* do not, however, exhaust the whole of this kingdom, but leave to be accounted for the *flowerless, seedless* plants, called *Cryptogames*, to which neither allusion nor of which direct mention is made in Genesis, it was conjectured, with due allowance for the difficulty of arranging them, and the consequent imperfection of their classification, that the plants of this description, or such as shall be declared *flowerless, seedless*, or *fruitless* had been willed into existence by previous fiats of the Creator during the period of the earth's non-rotation, and at those particular junctures when their agency was most required, while as yet there was no sun-light, and the Earth, being without rotation, was immersed in a universal ocean. On this account I was particularly desirous to explain the probable consequences of the indistinct line of separation between plants possessing perfect seeds and those having no claim to such, when investigations were being made amongst the orders of *Cryptogamia*, where these characteristics are involved in obscurity and uncertainty; and where, moreover, only vestiges of fossil plants form the objects of examination. Confirmed, however, in the belief that the *flowerless, seedless, fruitless* plants were *not* formed on the third day of the Mosaic week, but had been previously brought into existence, the attention was next directed to the character of the fossil remains themselves, by these being presented to the reader in abstract consolidated lists, with the additional evidence of the explanations and notes of those writers who have most dedicated themselves to the investigation of these objects of natural history,* and the result was, that a direct corroborative testimony was afforded as to the soundness of the leading views which had been adopted; the vast majority of the fossil plants being unconsciously declared—by men who never anticipated such an application of their evidence—to belong chiefly to the *cryptogamous* class of plants.

And, on the whole, it is considered to be hardly possible to meet with greater success in any similar enquiry than that which has been experienced in this branch of the argument. The conviction entertained of the truth of Scripture and of the Omniscience of its Author—Creator also of the objects of our research—when applied to the experience of botanists, led me to conclude *that a grand division of the vegetable kingdom had been created before the period of*

* See Appendix D.

rotation, and were of a description corresponding to the then condition of the world. On further research geological botanists were found busy with extensive repositories of fossil plants which they had dug up from the bowels of the Earth, and which—without any reference to the source of my information—they had described and classed as correctly as the peculiar circumstances attending their discovery would permit. And when the vestiges thus discovered were compared with those whose origin I was in quest of, the two were found to correspond in almost every particular; so much so that when their opinions agree—and this is happily the case with respect to the great majority of the plants—they concur in referring them to those *Orders* of imperfect plants whose formation is not recorded by the Sacred Historian: and wherein any are inclined to refer them to higher classes or orders, there is not unfrequently a difference of opinion amongst them; the plurality of votes seeming to be in favour of the assumption that disputed fossils belonged to the flowerless Cryptogames.

Having thus, with much care and success, surmounted the prefatory part of my labours in this section, I must now direct the attention for a short time *to the adaptation of those imperfect, flowerless plants to the condition of our planet at a period when it was without light, without diurnal rotation, and circumbounded by an atmosphereless ocean.* In doing this, I shall pursue a path somewhat similar to that which, in a corresponding part of the preceding section, was followed when shewing the close adaptation of the animals of the ancient world to the state of the Creation during their occupancy of the earth; and, to a certain extent, the constraint I am thus placed under, will add another, and no mean proof, to the many already adduced, of the justness of my views; *similar influential causes having produced, in either case, analogous results.*

I shall commence, therefore, by a detailed investigation into the nature and functions of the respiratory organs of plants, which principally consist of their green parts—the *leaves.*

The writer on Botany, in the *Library of Useful Knowledge* says—

"The stem of a plant is clothed with what are collectively called its appendages, or appendages of the axis, consisting of leaves and their modification, and of flowers with their parts. The former, taken with the stem itself, are called *organs of vegetation,* or nutrition; the latter of *fructification* or *reproduction.*

"*Leaves* are usually those expansions of the bark into which slender processes of the wood and fibre insinuate themselves, and within which, after shooting beyond the surface of the stem, they expand and branch in every direction, filling the whole of the pulpy substance with a net-work of tough and stiff fibres, which serve to sustain the mass of the leaf. The *leaf* is therefore in intimate connection with both parts; with the bark on the one hand, and with the wood on the other; consisting of the portions of the systems of these two important parts intimately intermingled, but each capable of acting singly as well as in concert. The pulpy substance which

expands from the surface of the bark and forms the principal part of the leaf is technically named the *parenchyma*, and the fibres that maintain it *veins*. The latter are also frequently called *nerves* or *nervures* in botanical language, although improperly; for they are merely channels through which fluids are impelled, and they have no connection, as far as we know, with any action resembling the nervous system of animals. . . . . .

"The universal presence of leaves upon all plants; their highly complicated structure; the intimate connexion which it has been shown they maintain between the systems of the wood and the bark; their extremely high development in many cases; and their multiplied variety of forms, all lead to the opinion that they are organs of the most essential importance. This is confirmed by their internal structure, independently of experiment.

"Most leaves are not thicker than a piece of paper or parchment, and appear to the naked eye as nothing more than a thin green plate, so that an ordinary observer would never suspect that their internal structure, which no eye, unassisted by glasses, can investigate, was one of the most complicated and highly organized character; and yet there is no part among those with which plants are furnished which is more complex. It is necessary, indeed, that it should be so, in order to be enabled to perform the important functions of digestion, respiration, and perspiration, for which it is destined.

"The anatomical structure of the leaf appears distinctly connected with its functions of respiration and evaporation. That side of the leaf which is next the sun being most exposed to heat, the cylindrical bladders that form it are placed with their narrow ends next the cuticle, by which means they not only each present the smallest evaporating surface, but are so circumstanced with respect to each other, as to be able with the least difficulty to absorb fluid from each other as they empty. The bladders next the lower surface not being exposed to the same kind of external influence, do not require the same kind of internal adjustment of their parts, but are arranged with wide intervals between them, which communicate with the chambers below the numerous breathing pores of the lower surface. Here, then, the functions of respiration are best performed: each bladder, on the one hand, exposes the greatest possible extent of surface to the action of the oxygen or carbonic acid that may be received by the breathing pores; and has, on the other, the greatest possible power of parting; firstly, with the oxygen which results from the decomposition of the carbonic acid in these vegetable stomata, and secondly, with the superfluous water which is not evaporated by the upper surface through the cuticle. It will be observed that in the water lily, in which the most cavernous part of the parenchyma is next the upper surface, the leaf floats with its lower face upon the water; respiration, consequently, cannot take place at the under surface, and the function, of necessity, is transferred to the upper, where the stomata all are.

"From these statements it is to be inferred that leaves are a sort of pneumatic apparatus, of a highly curious and elaborate structure; and that the variations which occur in their internal organization are beautiful adaptations of the parenchyma to the particular circumstances under which the leaves themselves are placed.

"Light, heat, and water, are the external agents which, acting upon the vital principle, set all the machinery of vegetation in motion. No one of these causes will, by itself, produce the effect, although their continuation be of the most powerful kind.

"Light, as we shall hereafter see, causes the decomposition of carbonic

acid, fixing the carbon in the interior of the tissue, and thus solidifying the more delicate parts, or altering the chemical nature of others. It is the grand cause of the varied colours of vegetation, and may be considered as being, in part, what produces a motion of the fluids. In its absence plants are weak, sickly, and soon perish.

"Heat, by drying the atmosphere, produces evaporation, which is one of the great means by which the crude fluids become inspissated and altered in their nature; it causes the expansion of the gases which plants contain, distends their tissue, and renders the latter more capable of performing its contractile and hygrometrical functions.

"Water relaxes all the parts, dissolves the soluble matters which are laid up in a plant in a state of torpidity, and softens the tissue till it is capable of receiving the influence of temperature. It is, moreover, the medium by which the nutritious principles that are deposited in the earth are absorbed by the roots, and conveyed from one part of the system to another.

"To sum up in a few words all that has thus far been stated, it is *light, heat, and water, acting in concert upon the irritable membrane, which enable plants, by virtue of their extensibility, elasticity, and hygrometrical powers, to perform the phenomena of contraction and endosmose, by means of which they absorb and digest their food, circulate their fluids, develope their organs, increase in size, and reproduce themselves.*"*

"Under the name of respiration, we shall include all that is connected with the inhaling and giving off of gaseous matter. This function is chiefly connected with the absorption of oxygen and carbonic acid, and their expiration. By a vast number of experiments chemists have determined that the green parts of plants placed in the sun absorb carbonic acid from the atmosphere, and decompose it, giving back the oxygen; and that at night they absorb oxygen from the atmosphere, giving off carbonic acid: it is also probable that they part with a small quantity of carbonic acid during the day. . . . . . These conditions are necessary in order to secure the disengagement of oxygen by leaves: firstly, the parts must be green; secondly, they must be exposed to the direct action of the solar rays; and thirdly, there must be carbonic acid in the water.

"The circumstance that green parts alone, with a few exceptions, are capable of giving off oxygen, sufficiently proves that it cannot result from what atmospheric air may adhere to the leaves under experiment. . . . . . That it is, in fact, a vital action is proved by dead leaves, still green, having no power of emitting gaseous matter until they begin to decompose.

"It is not sufficient to place leaves in bright light to procure the emission of oxygen by their leaves in water; it must be under the direct rays of the sun. De Candolle found the purest day-light, the brightest lamplight, insufficient to produce the phenomenon; a very curious result when we consider how large a part of vegetation is seldom exposed directly to the solar rays. Of course nothing like emission of oxygen would occur at night.

"From this and many other considerations, we are forced to conclude that oxygen is absorbed by plants at night. This gas does not, however, remain in the system of the plant in an elastic state, for neither the air-pump nor heat will disengage it; but it appears to incorporate itself with the tissue, since solar light readily disengages it. The inference therefore is, that it is absorbed at night, and combines with the carbon already exist-

* See 120th Theorem.

ing, forming carbonic acid, and that the latter is decomposed by the sun, as has before been shown. . . . . . From whence, it may be enquired, is the large quantity of carbonic acid obtained which is thus necessary to the support of plants? Certainly not from the atmosphere alone, for it does not usually contain one part in a thousand of carbonic acid. There can be no doubt that this gas is supplied principally by the Earth, in which it exists in great quantity; that a part is obtained from the atmosphere; and that a certain other portion results from the combination of the oxygen of the atmosphere with the carbon of vegetation; and it would seem as if a repeated decomposition and recomposition of carbonic acid was the principal phenomenon in respiration.* . . . . . Hence it appears that while animals vitiate the atmosphere by respiring carbonic acid, plants purify it by absorbing it. It may be said, indeed, that they also deteriorate it, by abstracting its oxygen; but it is to be remembered that if they inhale it at night, they return it in the day time. . . . . .

"What we have now seen of the action of the leaves and green parts of plants will enable us to appreciate the adaptation of their internal structure to perform their functions. We have found them to consist of a number of little cells or bladders, so loosely cohering that the air has room for free circulation between them; and that, by the way in which they are arranged, they present the greatest possible surface to the action of the atmosphere. Although they are enclosed in a thick cuticle, yet they are provided with openings through it, called stomates, by means of which free admission for air is secured, and through which it may be expelled again with facility when they are submersed, and are, consequently, neither exposed to irregularities of temperature nor of dryness in the air. . . . . . It is true that Mons. de Candolle entertains doubts whether the stomates are not rather organs of evaporation; but when we consider the relation they bear to the air cavities in leaves we can scarcely doubt that they are really respiratory organs; nor does it appear clear why they should not, in fact, perform the functions both of pespiration and respiration. If we hold a leaf of Laurustinus over a candle, so as to heat the air contained in it without burning the leaf itself, the air will be expelled through the stomates with such force as to extinguish the flame."†

In corroboration of the foregoing, I give the following quotations from Professor Henslow's work on Botany:—

"The first actual change produced in the sap is effected by a process analogous to animal respiration. The air is inhaled by the leaf and the fresh surfaces of other parts of the plant, and its oxygen then unites with the carbonaceous matters contained in the sap, and the result is carbonic acid. The greater part of this gas is then held in solution by the sap; and the whole, or very nearly the whole, azote which has separated from the oxygen is exhaled. Besides the carbonic acid thus formed by the plant itself, the trifling proportion everywhere found in the atmosphere is also inhaled; and a still larger quantity is introduced in the water absorbed by the spongioles. Hence it appears that a three-fold provision is made for maintaining a supply of this necessary ingredient.‡ So long as plants remain in

* See 124th Theorem.
† Botany, in Library of Useful Knowledge, pp. 21, 28—31, 79, 80, 87—90.
‡ 124th Theorem.

the dark, no fresh change takes place in this condition of things; the carbonic acid is retained, but is not fixed in the form of an organic compound. This further result requires the additional stimulus of light, and then the decomposition of the carbonic acid is effected; the carbon becomes fixed under the form of an organizable compound, and all, or nearly all, the oxygen with which it is united is exhaled into the atmosphere. . . . . . In animal respiration, the carbonic acid is immediately expelled from the lungs as soon as it is formed, and the function is then considered complete; but perhaps it would be more logical to divide the function of vegetable respiration into two processes, one of which should comprise the formation, and the other the decomposition of carbonic acid. . . . . .

"When all these parts of plants which are capable of assuming a green tint, but more especially the leaves, receive the stimulus of light, they immediately decompose the carbonic acid contained in the sap. The result of this action is the retention of the carbon, and the expiration of the greater part of the oxygen into the surrounding atmosphere. The most obvious effect produced by this fixation of carbon is the appearance of that green colour which we find in nearly all leaves and in some other organs. . . . . Many effects popularly ascribed to the action of air, are, in fact, due to the agency of light. Thus, trees which grow in elevated or in isolated situations are more vigorous than others of the same species which grow in forests or in shady places; and those on the skirts of a wood are finer than those in the interior. . . . . . The loss of light in stoves and greenhouses, by diminishing the effects of exhalation, renders plants more liable to be frozen than others of the same description which are growing in the open air.

"Although the decomposition of carbonic acid by the green parts of plants is perpetually carried on under the stimulus of diffused light, and its effects may even be rendered apparent by the action of lamp-light, which gives a slight tinge of green to plants when grown in a cellar, yet when plants are placed in the direct rays of the sun, the action is so much more rapid, that the oxygen may then be collected in sufficient quantity to produce a striking result.*

These explanations of the phenomena attending the organization, the respiration, and the evaporation of perfect flowering plants, together with the manner in which they form and decompose carbonic acid, are amply sufficient to shew that sun-light and atmospheric air are indispensably requisite for effecting those important functions of the vegetable economy; and, consequently, it is quite unnecessary to prove that none of the flowering plants requiring these essential elements could have existed previously to the formation of the light and of the atmosphere; and are, on that account, to be considered as not having, in any way whatever, contributed to those widely-extended and important labours performed by the agency of plants during the protracted period of non-rotation. They may, I therefore apprehend, after a few further explanations, be eliminated altogether from the future argument. They did not then exist.

But, to leave no lingering doubt unremoved, let it be next enquired whether they could have fulfilled the end of their being—their re-

* Botany, in Cab. Cyc. pp. 186—190.

production—had they been submerged in water. I shall first recapitulate the *hundred and eighteenth* Theorem: *That all the phenomena attending the flowering of plants and the dihescense of the various receptacles which are instrumental in the fertilization and maturation of the* SEED *and* FRUIT, *and the dissemination of the former, fully attest the absolute necessity of these* COMPLICATED OPERATIONS BEING CONDUCTED IN ATMOSPHERIC AIR. *The presence of much moisture being prejudicial to the peculiar development of the pollen;*" and, in continuation, I shall give a few corroborative extracts, although the Theorem itself is almost sufficiently conclusive:—

"It is further essential," says Professor Henslow, "that the pollen should be protected from the influence of moisture; and, consequently, we find that aquatics, as the water lily *(Nymphæalba)*, elongate their flower stalks until the blossoms float upon the surface of the water. In the water-soldier *(Stratiotes Aloides)*, water-voilet *(Hottonia Palustus)*, and others, the entire plants float to the surface of the water during the period of flowering, but live submerged at other times. In the *Zostera Marina* the flowers are arranged within a cavity filled with air; and thus, although they are developed beneath the surface, they are protected from the immediate contact of the water.

"If ripe pollen be placed in a tub of water and examined under a microscope, in a few seconds it will be seen to dilate, burst, and violently expel a cloud of minute granules. These granules are still contained within the inner membrane of the pollen grain protruded through the ruptured outer membrane, but which is difficult to be observed on account of its extreme tenuity. It thus forms a sort of rude sack, termed "a pollen tube," and contains a liquid, the 'fovilla,' in which are dispersed a number of very minute 'pollen granules.' . . . . . In consequence of the effect thus produced on pollen by water, it is liable to injury in rainy seasons, and the fertility of the seed is often impaired. . . . . .

"The salt of sea water produces an injurious effect upon the seeds of plants, and completely destroys the vitality of those which are long subjected to its influence."*

"When the flower unfolds," observes the writer on Botany in the *Library of Useful Knowledge*, "the anther is a tolerably solid, moist body, filled with moist pollen. The grains of the latter contain a fluid more dense than the tissue that forms a covering for them, and rapidly absorbs its moisture from the anther case. As soon as this has happened to any great extent, the tissue of the anther case contracts, and at first rends into grated cells of various forms; as the dryness is increased, these latter contract still farther, and exercising a general power over the whole surface of the lining would, in the end, be rent into still finer portions, if it were not for the slight degree of cohesion which exists between the valves of the anther at the sutural line."†

These quotations, which I have considered necessary to give as succinctly as possible, sufficiently prove, that atmospheric air is not more essential to the entire phenomena connected with the

* Botany, in Cab. Cyc. pp. 263, 266, 303.
† Library of Useful Knowledge, p. 109.

development and reproduction of the *Monocotyledonous* and *Dicotyledonous* plants than that an undue degree of moisture is prejudicial to these functions: consequently, deprivation of the light and atmospheric air and submersion in water would have been altogether destructive of those important processes in *flowering* plants. They could not, in such a condition, have existed. But, on the other hand, as the most perfect wisdom pervades the whole design of Creation, it is but just to conclude that an adequate motive existed for the adoption of whatever principle may be evidently traceable in it. There is a principle peculiarly observable in the formation of the Vegetable Kingdom. The two great classes of plants which were called into existence *after* the formation of the light, the atmosphere, and the "dry land," were *flowering* plants, whose submersion in water, as has just been made apparent, would have been wholly destructive of their propagation; while those which existed before were *flowerless* plants, possessing neither stamen, stigma, nor pollen, radicle nor plumule; therefore it is allowable to conclude that light or atmospheric air was not indispensably essential, nor was water inimical to the maturation, or to the subsequent development and germination of their reproductive organs, whether these were sporules, cones, or dot-like bodies.

SECTION II.

THE VEGETABLE ORGANISMS OF THE NON-ROTATORY PERIOD.

CHAPTER VI.

The assumed condition of the primitive vegetation compared with Botanical descriptions of Cryptogamous Plants. Characters and habitats of these given in detail, and found to coincide with the supposed state of the Submerged Vegetation of the anti-rotatory period. Motives for supposing that there was only one general elevation of the terraine portion of the earth. The absence, in lists of fossil flora, of certain orders of Acotyledonous Plants accounted for. Capability of plants growing in the waters of the primeval ocean, although this held in solution saline materials.

THE important results which were come to at the conclusion of the preceding chapter will be greatly confirmed should it be found that what was deduced from reasoning, *a priori*, agrees with that which experimental botanists declare to prevail amongst the interesting objects of the vegetable kingdom now under consideration; for, if those two branches agree, we can scarcely any longer entertain a doubt. According to the consolidated lists which have been given, the plants found in the stratified masses, which have been identified and classed, consist of 1. Algæ. 2. Filices. 3. Characeæ. 4. Lycopodiaceæ. 5. Marsileaceæ. 6. Equisetaceæ. 7. Naiades or Fluviales. 8. Cycadeæ. 9. Euphorbiaceæ, with a few Coniferæ and Palmæ, some Cannæ, and others still uncertain as to class and genera, which consequently cannot be taken into account. But to those which have been identified I shall affix, in the order in which they stand, a succinct account of their usual *characteristics* and *habitats*.

"ACOTYLEDONS.

"ORDER III. ALGÆ.—*Vegetables*, for the most part aquatics, destitute of roots, or furnished only with a fibrous or scutate base for the purpose of attachment merely; having, for fructification, *seeds* or *sporules*. . . . . .

"Many species of this singular, and, generally speaking, beautiful order of plants, frequently float in the water without any point of attachment to extraneous substances. Their colour is various, often green, brown, red, &c."*

And, again, from the pen of an amiable naturalist, who has dedi-

* Flora Scotica, part ii. p. 74.

cated much of his attention to this humble but interesting order of the "Algæ," we have the following in his recent publication:—

"*Algæ* form part of that great Class to which Linnæus has given the name of Cryptogamia, because they are flowerless; but, like ferns and mosses, and other plants of the same great class, they possess what answers the purpose of flowers. . . . . The fronds of Algæ are not only variable in form but also in substance. Some are like masses of jelly; others are very gelatinous; others are like silk threads; others are cartilaginous; some as tough as leather; and others as firm as wood. . . . . The prevailing colours which they exhibit are green, olive, and red, in all their variety of shades. Those of a green colour generally grow in shallow water, the olive in deeper, and the red in deeper still, although in these respects there are several exceptions. . . . .

"Algæ, or sea-weeds, have a wide geographical range, for I suppose wherever there is sea, sea-weeds of some kind are found. To a considerable extent, they seem to obey the same laws as land plants. Every zone presents a peculiar system of vegetation."*

"ORDER VII. FILICES.—*Fructification* only of one kind on the same individual. *Capsules* spiked or racined, or mostly collected into *clusters* of various shapes (sori) upon the back of the *leaf* or *frond*, naked or covered with an *involucrum*, often surrounded by an elastic *ring*, opening irregularly, or without a *ring*, and opening with a regular *fissure*. *Seeds* or *sporules* minute. . . . . In the tropics the *caudex* forms a *trunk* resembling that of the palms."†

Of the stations of the various species enumerated, eight are particularised as being in "marshes and bogs;" "woody and wet rocky places;" "rocks by the sea-side;" "wet rocks and along the shores of Loch Lomond (the *osmunda regalis*, the largest and handsomest of the British ferns);" and "meadows and moist places." The remainder seem to prefer shady woods and fissures of rocks.‡

MM. de Candolle and Sprengel (in the Elements of the Philosophy of Plants), say—

"The remains of the former vegetable world belong almost entirely to the lower families; they consist for the most part of Grasses, Reeds, Palms, and Ferns, *the latter being almost always destitute of fruit*."§

According to Professor Henslow—

"In the oolitic series fossil plants become more abundant, and some beds are remarkably characterized by the prevalence," amongst others, "of many ferns very distinct from those in the former formations."||

"A Fern," says Mr. Francis, "is a flowerless plant, which has a fibrous root, vascular stem, veined leaves, reticulated cuticle furnished with stomata, and bears spores as fruit in capsular receptacles. The Ferns and their allies form the first order of the Linnæan class CRYPTOGAMIA, and their structure shows such an intermediate character between the Vasculares and Cellulares, that all systems of classification have assigned them this station

* Popular History of British Algæ, by the Rev. Dr. Landsborough, 1849, pp. 9—35.
† Flora Scotica, part ii. p. 152. ‡ Ibid, pp. 152—158. § Ibid, p. 276.
|| Botany, in Cab. Cyc. p. 312.

among vegetables. They are without flowers, have but imperfectly formed vessels, and no deposition of real woody fibre, therefore cannot with propriety be arranged with Phanogamous plants, while their semi-vascular texture, and their fully developed leaves shew their organization to be greatly above that of any other order of cryptogamic plants.

"Although the True Ferns have a direct analogy with the Palmæ and Cycadeæ, the connexion between them and other orders is more apparent in the Pteroides or Fern Allies, particularly the Equiseta and Lycopodia. . . . . . . Thus the tribes under consideration, which are divided according to the modern system into Filiciales, Lycopodales, and Equisetales, the first the True Ferns, the other the Pteroides or Fern Allies, altogether form valuable, because well-connecting links in the great chain of nature.

"Ferns abound chiefly in the more woody and moist countries. Our larger species luxuriate on the banks of ditches. . . . . .

"Moisture and shade are equally necessary to all the Fern tribe; they grow, therefore, for the most part, in northern aspects, and on damp porous stones."*

"The reproduction of ferns," continues the same author, "is a subject involved in much obscurity. Hedwig, Bernhardi, and others have proposed theories to explain this intricate matter, but without success. . . . . . At present nothing whatever has been discovered of the origin of the germinating principle in any of the cryptogamic orders; nor the laws which regulate the formation and development of their spores.

"As regards our present tribe, so keen has been the search, that every part of the plant has been subjected to the minutest investigation; not only the thecæ, their ring, and their cover, but the spiral vessel of the rachis, the stomata upon their cuticle, and the glands which are sometimes found attending upon them."†

Order IV. Characeæ.—*Fructification* of two kinds. Nucleus 4, bracketed, standing solitary, &c. *Seeds*, or *sporules*, very minute, whitish, spherical, &c.

"*Vegetation*. Aquatic plants never rising above the surface of the water, fixed into the mud by slender fibrous radicles issuing from a swollen portion of the stem," &c. "A minute fossil body frequently found in chalk, which is spirally twisted, and which was formerly considered to belong to the animal kingdom, is, I believe, now generally allowed to be the *kukule* of *chara*. Various species have been discovered, and they are called by the French, gyrogomites."‡

"As the *chara*," says Mr. Lyell, "is an aquatic plant, which occurs frequently fossil in formations of different eras, and is often of much importance to geologists in characterising entire groups of strata, we shall describe the manner in which the recent species have been found in a petrified state. . . . . . In some species, as in *chara hispida*, the plant, when living, contains so much carbonate of lime in its vegetable organization, independently of calcareous incrustation, that it effervesces strongly with acids when dried," &c.§

"Order VIII. Lycopodiaceæ.—*Fructification* bracteated, auxiliary, or

* Francis on Ferns and their Allies, 1837, Introduction, pp. 1, 2.
† British Ferns, p. 5.
‡ Flora Scotica, part ii. pp. 108, 109.
§ Principles of Geology, vol ii. pp. 280, 281.

spiked. *Capsules* frequently of two kinds on the same plant, 1-3 celled, 2-3 valved, containing many minute *granules;* or a few larger *corpuscles.* Roots fibrous. *Stems* herbaceous or woody, simple or branched, often creeping. Of five *habitats,* two are 'wet heathy places, and by the sides of lakes,' and 'boggy places by the sides of rivulets on the highland mountains,' the others are on rough, stony, heathy mountains."*

Mr. Lyell explains *Lycopodineæ* as

"Plants of an inferior degree of organization to coniferæ, some of which they very much resemble in foliage, but all recent species are infinitely smaller. Many of the fossil species are as gigantic as recent coniferæ. Their mode of reproduction is analogous to that of ferns. In England they are called club-mosses."—*Glossary,* p. 72.

"Order IX. Marsileaceæ.—*Fructification* radicle. *Involucrum* subsperical, not opening, coriaceous, or membranaceous. One or many celled. Aquatics. *Hab.* bottoms of the highland lakes, and damp places that are overflowed during winter, but not common, &c."

"Order X. Equisetaceæ.—*Fructification* terminal, spicate, consisting of peltate polyognous scales, on the under side of which are from 4-7 involucres, which open longitudinally, and contain numerous naked (?) seeds, unfolded by four filaments bearing anthers (?) at their extremities.

"*Vegetation.* *Stems* rigid, leafless, jointed, striated, the articulations sheathed at the base, the branches whorled.

"*Habitat,* 'wet marshes;' 'shady marshes,' and 'the brinks of stagnant waters;' 'moist shady places;' 'lakes and ditches;' 'ditches and wet soils.'"

"MONOCOTYLEDONS.

"Order XVIII. Fluviales.—(*Part of Naiades. Juss.*)—Flowers unisexual or bisexual. Ovary 1 or more superior. *Seed* solitary, pendulous, or suspended. *Embryo* without *albumen,* having a contrary direction to the *seeds,* with a lateral *cleft* for the emission of the *plumule.* Floating *herbs* with very vascular leaves and stems. *Flowers* inconspicuous."†

CYCADEÆ.

By referring to Messrs. Lindley and Hutton's Fossil Flora, it will be perceived, that the fossils classed under this *Order* are known only by their leaves, and are found in the lias, the oolite, and the grey chalk formations.

"The *Cycadeæ* form the passage from the *palms* to the *ferns.*"—*Sprengel.*

"The *Cycadeæ* have great proximity to the ferns."—*Lindley.*

"The associated fossil plants (in the coal formation), although imperfectly known, tend to the same conclusion (an elevated temperature), the *Cycadeæ* constituting the most numerous family."—*Lyell,* vol. i. p. 116.

In addition to these descriptive notices it is considered opportune to subjoin a few extracts of a more general character. They will

* Flora Scotica, p. 159.

† Flora Scotica, part ii. p. 192. The *Naiades* are placed by MM. de Candolle and Sprengel, in their Elements of the Philosophy of Plants, amongst the Acotyledons. See p. 139.

likewise prove the extreme warmth which everywhere prevailed during the period now alluded to.

"We learn," says Mr. Lyell, "from the labours of M. Ad. Brongniart, that there existed at that epoch during the formation of the Coal measures, Equiseta upwards of ten feet high, and from five to six inches in diameter; tree ferns of from forty to fifty feet in height, and arborescent Lycopodiaceæ of from sixty to seventy feet high. Of the above classes of vegetables, the species are all small at present in cold climates; while in tropical regions there occur, together with small species, many of a much greater size, but their development at present, even in the hottest parts of the globe, is inferior to that indicated by the petrified forms of the coal measures. An elevated and uniform temperature, and great humidity in the air, are the causes most favourable for the numerical predominance and the great size of these plants within the torrid zone at present." In a note to this paragraph it is added, "Martins informs us that on seeing the tessellated surface of the stems of the arborescent ferns in Brazil, he was reminded of their prototypes in the impressions which he had seen in the coal mines of Germany."*

Mr. Miller, in his usual graphic style, expresses himself, with respect to this uniformity of ancient flora, in the following remarkable words:—

"In the more ancient geological periods, ere the seasons began, the case is essentially different. The contemporary formations, when widely separated, are often very unlike in mineralogical character, but in their fossil contents they are almost always identical. In these earlier ages, the atmospheric temperature seems to have depended more on the internal heat of the earth, only partially cooled down from its original state, than on the earth's configuration, or the influence of the sun. Hence a widely-spread equality of climate—a green-house equalization of heat, if I may so speak; and hence, too, it would seem a widely-spread flora. The green-houses of Scotland and Sweden produce the same plants with the green-houses of Spain and Italy; and when the world was one vast green-house, heated from below, the same families of plants seem to have ranged over spaces immensely more extended than those geographical circles in which, in the present time, the same plants are found indigenous.

"The fossil remains of the coal measures are the same to the westward of the Alleghany Mountains as in New Holland, India, Southern Africa, the neighbourhood of Newcastle, and the vicinity of Edinburgh. And I entertain little doubt that, on a similar principle, the still more ancient organisms of the old red sandstone will be found to bear the same character all over the world."†

Although Sir Henry de la Beche's opinion has already and so recently been put on record, yet, as it is of interest, I again briefly recur to it:—

"Respecting the general character of the vegetation which we find entombed in the carboniferous rocks of the Northern hemisphere, M. Ad. Brongniart observes, that it is remarkable, 1st, for the considerable propor-

* Principles of Geology, vol. i. pp. 116, 117.
† Old Red Sandstone Formations, pp. 197, 198.

tion of the vascular cryptogamic plants, such as the *Equisetaceæ, Filices, Marsileaceæ,* and *Lycopodiaceæ;* 2nd, for the great development of the vegetables of this class, proving thereby that circumstances were particularly favourable to their production during the period under consideration. . . .

"This view leads us to another consideration. There certainly was a similar vegetation about the same period (for whether the American coal measures may be, like those of Ireland, somewhat older, does not alter the question) over parts of Europe and North America; we may, therefore, infer a similar climate over a large portion of the Northern hemisphere, such as we have not at present, for it was at least tropical, and very probable ultra-tropical."*

Professor Henslow observes—

"Many local circumstances produce remarkable modifications in the relative proportions between the species of different classes and orders in regions under the same parallels of latitude. Thus, for instance, *ceteris paribus,* the cryptogamic tribes flourish most in moist regions. The places best adapted to the growth of ferns are the islands in tropical climates, in some of which, as in St. Helena, one half of the flora is composed of them. It is remarkable that in this respect, and as regards the existence of arborescent species in this order, the ancient flora of our coal fields appears to approximate very closely to that of islands situate in the midst of an extended ocean and in low latitudes. The same causes which appear favourable to the increase of cryptogamic species, seem also to produce a diminution in the proportions which dicotyledons bear to monocotyledons."†

I shall conclude this part of the evidence with a few sentences from the work of those indefatigable fossil botanists, Messrs. Lindley and Hutton:—

"In the *coal formation,* which may be considered the earliest in which the remains of land plants have been discovered, the *flora* of England consists of *Ferns* in amazing abundance; of large *Coniferous* trees of species resembling *Lycopodiaceæ,* but of most gigantic dimensions; of vast quantities of a tribe analogous to *Cacteæ* or *Euphorbiaceæ,* but perhaps not identical with them; of some *palms* and other monocotyledons, and, finally, of numerous plants the exact nature of which is as yet extremely doubtful. About two to three hundred species have been detected in this formation, of which two-thirds are *Ferns.* . . . . This vegetation, thus inconceivably rich and luxuriant, grew amidst an atmosphere that would have been fatal to the animal kingdom, ... in consequence then of the greater abundance of carbonic acid gas than now. . . . . . . To this there are no botanical objections: whether such an atmospheric condition was unfit for animals is not our province to enquire. . . . . . .

"It may be observed that no trace of any *glumaceous* plant has been met with, amongst the fossil flora, even in the latest tertiary period; although we know that *grasses* now form a portion, and usually a very considerable one, of every recent *flora* of the world, from New South Shetland to Melville Island inclusive; it may, indeed, be conjectured, that before the creation of herbiverous animals, grasses and sedges were not required, and, therefore, are not to be expected in any strata below the Forest marble and Stones-

* Manual of Geology, 2nd edition, pp. 429—431. † Botany, in Cab. Cyc. p. 309.

field slates, but it is difficult to conceive how the animals of the upper *tertiary* beds could have been fed if grasses had not then been present."*

The general impression left upon the mind, after perusing these copious extracts, is, that the plants which constituted the carboniferous portion of the coal measures delighted in warmth, carbonic acid gas, and moisture, and having enjoyed these three requisites in an abundant degree, they increased to gigantic proportions when compared with recent equivalents: while the more particular inferences to be drawn from the same quotations are, that with respect to the *Algæ, Marsileaceæ, Equisetaceæ, Naiades*, and *Characeæ*, undoubted evidence has been adduced, to prove, *that water being their natural element, in it they grow and propagate.* But it is not equally conclusive with respect to the remaining orders, the *Filices, Lycopodineaceæ*, and perhaps the *Cycadeæ;* for it has only been shown that certain of their species prefer moisture, and the proximity of water as their favourite localities.

However, when in unison with Professor Henslow, it is considered, that "fossils bear an analogy to some recent genera, which they closely resemble, but to which they cannot be accurately referred; the resemblance being indicated by classifying them provisionally with a genus; for example, 'Lycopodites,' a genus of fossil plants allied to 'Lycopodium,' but too imperfectly known to have its characters fully pointed out;"† and at the same time discover, by a glance at the several *habitats* of the *Filices*, such a diversity in their *stations*, and consequently in their nature, as to induce the *Asplenium alternifolium* to flaunt in the sunny crevices of Alpine rocks, while the graceful *Osmunda regalis* dips in the waters of the lakes which are formed by these mountains, it will not surprise any one if but little anxiety should be entertained as to the eventual decision of the question; for it may ultimately be discovered, that the fossil *Ferns, Lycopodineaceæ*, and *Cycadeæ*, were of a nature capable alike of growing and propagating under water; and as I shall hereafter have occasion to show, *that unless they grew under water they did not grow at all*, while by their remains found in the ancient strata, their existence cannot for a moment be doubted, the only inference which can be drawn is, *that they grew submerged in the ocean which circumbounded the Earth during its period of non-rotation.*

But it must not be supposed that all the difficulties in endeavouring to explain this hypothesis have been overcome. Very far from it. We are scarcely across the threshold; and I am exposed to the imminent danger of proving too much on the one hand, or too little on the other. Indeed, peculiarities of those two kinds obtrude themselves as obstacles to any advance whatever. It may

* MM. Lindley and Hutton's Fossil Flora, Introduction, vol. i. pp. x. xi. xxiii.
† Botany, in Cab. Cyc. p. 311.

be considered that I have "proved too much," unless satisfactory reasons can be given for the absence of several orders of *cryptogamic* plants which, on the supposition that all of this class were excluded from the creative command on the third day of the Mosaic week, should, consequently, have been discovered amongst the fossil remains of the *ancient flora;* but which are not generally mentioned by geological botanists as forming part of their collections; and, on the other hand, I run the risk of having "proved too little," unless I can explain the state of the primeval water so satisfactorily as to show that plants usually requiring *fresh water* could have lived, grown, and propagated at the bottom of the original circumfluent ocean. These difficulties will be taken in the order in which they stand, and I shall, therefore, first endeavour to account for the absence of *Fungi, Lichens, Hepaticeæ,* and *Musci,* which have not been discovered fossil or perfectly identified in any of the geological formations below the chalk;* while it must be remembered, that the point being wholly negative, the proofs, to the limited amount obtainable, will partake of the same character.

"ACOTYLEDONS.

"ORDER I. FUNGI, *Linn.* (*Fungi, and part of Algæ, Juss. Fungi, and part of Hypoxylia, Decand.*—Plants growing upon the ground, or parasitic on other vegetable substances, rarely (never?) aquatics, and scarcely ever green, filamentous, gelatinous, spongy, corky, coriaceous, fleshy, or membranaceous. . . . . . . The *seeds* or *sporules* are either internal, as in *Sphæria,* Bovista, or external, as in Agaricus, &c. After being once dried, they do not revive by the application of moisture, like the greater number of plants in this class; and, generally speaking, they are of very short duration, soon decaying, and frequently becoming putrid in decay."†

"ACOTYLEDONS.

"ORDER II. LICHENS, *Ach.* (*Lichens, and part of Hypoxylia, Decand. Part of Algæ, Juss. Genus Lichen, and some Byssi, Linn*).—*Universal recept,* (*thallus, crust, or frond*), polymorphous, without roots, perennial, abounding in excessively minute bodies for the purpose of propagation, either embeded in the substance or scattered upon its surface, or included in peculiar organs, which have been considered the *fruit* (partial receptacles, or *apothecia;* by some called *shields* or *scutella* and *tubercules*)."‡

"With regard to the most simple forms of vegetation," says the writer

* Since writing this, I have seen the following corroborative passage in MM. Lindley and Hutton's Fossil Flora, vol. i. p. xviii., when they were endeavouring to combat the opinion of M. Ad. Brongniart and his reviewers, "that nothing but *cryptogamous* and *monocotyledonous* plants existed in the Coal measures," they ask, "what trace is there of the simplest forms of flowerless vegetation in the Coal measures, such as *Fungi, Lichens, Hepaticeæ,* or *Mosses?* to say nothing of *Confervæ.* Many of these would have communicated their casts as distinctly to the matter which enclosed them as *Ferns* or *Lycopodiaceæ,* had they existed; but no traces of them are found; while we have," say they, "on the contrary, in their room, the most perfectly organized plants of the Flowerless or Cryptogamic class, namely, *Ferns, Lycopodiaceæ,* and supposed *Equisetaceæ.*"

† Flora Scotica, part ii. pp. 3, 4. ‡ Ibid, part ii. p. 35.

on botany, from whom we have so often quoted, "such as *Fungi*, *Lichens*, and *Sea weeds*, the subject is involved in so much greater mystery (than the higher bodies of cryptogamic plants), that there are to this day botanists of no mean reputation who believe such plants to be produced by means almost analogous to equivocal generation."*

"ACOTYLEDONS.

"ORDER VI. MUSCI.—"Fructification of two kinds. *Capsules*, in an early stage, covered with a calyptra, tipped with a style, which bursts transversely and regularly, and rises up mostly with a pedunculated and operculated capsule, ... and spherical pedicellated reticulated *bodies*, concealed for the most part in peculiarly shaped leaves, which have been considered *anthers*. *Plants* of small size, of a more or less compactly cellular structure, readily reviving by the application of moisture after being dry.

"The following are some of the *stations* of this extensive and widely-extended order of plants. To avoid being diffuse the *genera* only have been particularised :—

SPLAGNUM—Bogs, marshes, and growing in water in boggy places.
GYMNOSTOMUM—Wet and moist rocks, ditches, and banks near the sea.
WEISSIA—Turf bogs, and oozy shady rocks, clayey places, and moist banks.
DICRANUM—Moist banks, marshes, very wet situations, and sides of streams and rivers.
TRICHOSTOMUM—In rivulets. Moist banks.
FONTINALIS—Rivers and lakes. Alpine and sub-alpine rivulets.
HOOKERIA—Moist banks in woods, &c.
HYPNUM—Banks of rivers and lakes, and spots occasionally overflowed with water. Bogs and marshy places."†

"ACOTYLEDONS.

"ORDER V. HEPATICÆ. *Juss. Decand. (part of Algæ, Linn. Calyptratæ Deoperculatæ, Mohr.)*—*Fructification* generally of two kinds. *Capsules* in an early stage covered with a *calyptra*, tipped with a style (?), and then often surrounded by a *perianth* or *calyx*, at length bursting the calyptra irregularly. *Minute plants*, frequently frondose, sometimes (as in Jungermannia) foliferous; *substance* loosely cellular in general, easily reviving after being dried, by moisture. Sometimes the areclæ of the cells have an evident pore, as in *Marchantia* and *Targionia*.

"The following are some of the *stations* of the *genera* belonging to this order :—

RICCIA—Turfy marshes among the Scottish mountains.
JUNGERMANNIA—Moist rocky places, marshy grounds, bogs, and boggy places, and growing in water.
TARGIONIA—Moist banks.
MARCHANTIA—Shady moist rocks, wet rocks and banks, and moist shady banks by the sides of rivulets."‡

These evidences are all that recent botany affords; and they amount to very little, as they merely prove the imperfect, rudi-

* Library of Useful Knowledge, p. 118. † Flora Scotica, part ii. pp. 120—152.
‡ Ibid, part ii. pp. 109—120.

mentary character of the missing plants, and their capability of having existed in moist, wet places, or perhaps submerged in some of their conditions; but they afford a very slender clue indeed when it is sought to unravel the mystery of their *non-appearance* (I would not say *absence*) amongst their associated Orders in the fossil remains of the primitive world. I must, therefore, turn with increased earnestness to collate from the writers on *fossil* botany whatever they may have put on record in this matter. The Orders of the inferior plants to be accounted for, are, 1st. *Fungi;* 2nd. *Lichens;* 3rd. *Hepaticeæ;* and 4th. *Musci.* Now, I find that indefatigable investigator Dr. M'Culloch, expressing himself thus: "I have proved in the Geological Transactions what has been denied, namely, that minute vegetables are preserved in chalcedony. These are the so-called Moss Agates. . . . . . . In my collection there are three or four *mosses*, one possibly a *Jungermannia*, and a *Lichen*, which admit of no dispute."* As *Jungermannia* is an *Hepaticeæ*, and he alludes besides to a *Lichen*, and to some *Mosses*, we have thus three of the *Orders* in question accounted for in one short, but pithy sentence, in which the writer points to proof positive, asserting that in his collection those fossil vegetables exist, may be examined and believed in, for they "admit of no dispute."†

Mr. Lyell—when engaged in that part of his geological treatise which required him to explain the origin of peat—states, that

"The generation of peat when not completely under water is confined to moist situations, where the temperature is low, and where vegetables may decompose without putrifying. It may consist of any of the numerous plants which are capable of growing in such *stations;* but a species of moss *(sphægnum palustre)*, constitutes a considerable part of the peat found in marshes of the north of Europe; this plant having the property of throwing up new shoots in its upper part, while its lower extremities are decaying. . . . . . Reeds, rushes, and other aquatic plants may usually be traced in peat; their oganization is often so entire that there is no difficulty in discriminating the distinct species."

At another place he says—

"From the researches of Dr. M'Culloch it appears that peat is intermediate between simple vegetable matter and lignite: the conversion of peat into lignite being gradual, and being brought about through the lapse of time, and the prolonged action of water."‡

But, perhaps, no evidence whatever can be more conclusive on this point than that which is afforded by the experiments of Professor Lindley, an account of which I prefer taking from Dr. Buckland's Bridgewater Treatise, as thereby their conjoint testi-

* Geology, by Dr. M'Culloch, vol. i. p. 414.

† In the *Fossil Flora*, *Musci* and *Characeæ* will be found, Gen. 84, 85, but both above the chalk.

‡ Principles of Geology, vol. ii. p. 216, 217.

mony is acquired, which, on a subject of this description, must be considered paramount to any other.

"The following are the results of Professor Lindley's experiments on the *durability* of plants immersed in water; 177 specimens, including representatives of all those which are either constantly present in the coal measures, or as invariably absent, having been immersed in a tank of water for two years, he found

"1. That the leaves and bark of most *dicotyledonous* plants are wholly decomposed in that period, and that of those which do resist it, the greater part are *coniferæ* and *cycadeæ*.

"2. That *monocotyledons* are more capable of resisting the action of water, particularly palms and *scitamineous* plants; but that *grasses* and *sedges* perish.

"3. That *fungi*, *mosses*, and all the lowest forms of vegetation disappear.

"4. That ferns have a great power of resisting water if gathered in a green state, not one of those submitted to the experiment having disappeared; but that their fructification perished."*

The result of this evidence respecting those minor classes of the *cryptogamous* plants whose infrequency amongst the *fossil* specimens, found in the strata, has occasioned this enquiry, seems to be, that while, on the one hand, the experiments of Professor Lindley afford sufficient reason for removing any anxiety which might arise from their prevailing absence, where fossil remains of other orders are so abundant; the testimony, on the other hand, of Dr. M'Culloch and concurring writers shows, that they are occasionally met with in a fossilized state; thus making it manifest that the experience of fossil botanists corresponds precisely with what might have been expected from the perishable nature of those minute cryptogamous plants, and the attendant circumstances during the period of their existence: a corroboration which ought entirely to remove any lurking doubt that may have remained.

Generally, it may be asserted with regard to them, that their rudimentary character—forming, as by concurring testimony they seem to have done, the primary elements in coal through its gradations of peat, lignite, &c.—would necessarily expose them to be wholly obliterated by transmutation during a lapse of ages into carbonaceous material; while, in other cases where circumstances were not conducive to their transmutation into coal, the effects produced by immersion, as shown by Professor Lindley, may have taken place, and the rudimentary, perishable descriptions of plants have disappeared, although the higher and more robust grades of cryptogames resisted the action and became fossilized.

It has not unfrequently occurred to me that, reposing with confidence on the truthfulness of the record of Scripture, and on the soundness of the views adopted by its assistance, I might have left this question to adjust itself in the course of time, and when

* Professor Buckland's Bridg. Treat. vol. i. pp. 410.

discussion had more thoroughly brought to light the direction which the line of separation takes between *flowering* and *flowerless* plants in the Vegetable Kingdom. Perhaps, indeed, I would not have mooted this question at all, had it not been from a feeling, something between a desire to leave no weak point behind me unexplored, and that of pushing my principle as far as it will go; and with it to test the soundness of the conclusions of those who have dedicated themselves to the fields of labour through which we are now wending our way. Should it be considered rather too bold an attempt, in the present state of the question, to endeavour to reconcile and thoroughly to make at one so general an assumption as the *non-rotation of the earth while darkness reigned over it*, with the minute and intimate nature, habits, and perfect adaptation of the lowest *orders* in the most inferior *class* of plants; and that, too, notwithstanding the divergency of opinion prevailing amongst botanists as to their systematic classification, it must be attributed only to the perfect confidence in the general soundness of my views, and in the firmness of the foundation on which they all repose; while it certainly adds greatly to their corroboration to find that, without the slightest diminution of confidence, it is precisely at the same point where botanists have not sufficiently made up their minds as to the classification of the objects of their research, that I also begin to falter and be at a loss how to proceed. I firmly believe that the faithful application of the comprehensive rule laid down in Scripture will clear up both of our paths, and show us *that although during the protracted period of non-rotation and darkness there existed at the bottom of the atmosphereless ocean innumerable families of plants, not one of them was furnished with any traces of either flowering or seeding processes*, in the true and full acceptation of these terms. That, in fine, although for ages previously there had been myriads of what are now called *imperfect* flowerless plants secreting carbonaceous material for future purposes, there was not, until the period represented by the third day of the Mosaic week, a single perfect or flowering, seeding plant within the whole range of the solar system!

The difficulty of another description, to which I alluded, namely, that of "proving too little," still remains to be disposed of. For, after it has been made out that the whole of the objects comprising the *cryptogamous* class of plants have been discovered in a fossil state, and that they could have existed and propagated in a submerged condition, the doubt still remains whether they could have done so *in the waters of the primeval ocean*, considering them to have been impregnated with saline materials, as manifested, amongst other vestiges, by the extensive deposits of salt found in the new red sandstone, and other associated formations. Before, however, this explanation can be satisfactorily given, or conclusively understood and relied on, my labours will require to be considerably more advanced. Then I have little doubt but I shall make it abundantly

evident, that although in reality the waters of the primeval ocean did contain all the elements which go to the formation of salt, yet other co-existent ingredients held these in a different state of combination, and caused the entire mass to be altogether distinct from the saline waters of the present seas. I shall then, also, be in a position satisfactorily to account for the deposition of culinary and other native salts in the new red sandstone and associated formations, and thus at one and the same time remove two obstacles to the complete establishing of the one great fact, *That during a long but indefinite period of its early geological history, the Earth did not rotate around its axis.*

SECTION II.

THE VEGETABLE ORGANISMS OF THE NON-ROTATORY PERIOD.

CHAPTER VII.

Another brief review of the progress made, and its application to the development of the general argument. Adaptation of the Plants of the non-rotatory period to the state of creation during that epoch. Fronds and foliaceous appendages of Cryptogames described—contrasted with the respiratory expansions of Phanogames; and the design of the former being demonstrated, they are shown to be in harmony with the effects which the flowerless plants were intended to produce, namely, absorption from the surrounding water, retention of carbonic acid, and deposition, by their roots, to assist in forming the carboniferous strata. Short concluding observation: the continuity with which the subject has been traced to the present convergent point.

Having reached another convenient resting place, we may again look around for a moment on commencing this chapter, to consider what has been done, and to see how far we have advanced in the general argument. When we had acquired a sufficiently accurate knowledge of the distinguishing characteristics of the three classes into which all known plants are grouped by the natural system of botany; and had compared them, thus arranged, with the comprehensive description given in Scripture of the creation of vegetable substances, it was found that the latter had reference merely to *seeding* and *fruit bearing* plants, *to the exclusion of all others*—a singular anomaly which constrained us to look elsewhere and to other manifestations of creative energy for the origin of the *flowerless, seedless, fruitless* plants. During this research it was perceived that writers on fossil botany had announced their having discovered amongst the stony tombs of earlier geological periods, the fossilized remains of plants, some of them in perfect preservation, resembling in almost every respect the *Cryptogames* or *Acotyledons,* whose origin we were in quest of: a remarkable coincidence in epoch, locality, and character, of no small importance to the argument, and leaving little doubt on the mind, that the command given on the third day of the Mosaic week had exclusive reference to the two more perfect classes of flowering, seeding plants in correspondence with the altered condition of our planet after the formation of the light; whilst the *Cryptogames* had existed during the period of darkness or of non-rotation. This led to a new set of enquiries, namely, to

prove the adaptation of this latter class to the primeval condition of the earth; but as direct evidence of this was not attainable, I endeavoured indirectly to make good that position, by showing that the two other classes, comprising the flowering plants, could not possibly have then existed; although these disabilities neither militate by assumption, nor yet by the direct experience of botanists, against the possibility of at least the greater proportion of the cryptogamous plants, or plants analogous to them, growing in the supposed circumstances of the earth previous to its rotation. These enquiries brought out, in the clearest manner possible, that the respiratory functions of plants, which reside in their leaves and other green parts, together with the decomposition of carbonic acid, and the fixation of carbon, depend on the direct light of the sun's rays acting upon these foliaceous appendages;* facts at direct variance with a state of matters which would apply to plants existing during the non-rotatory period, and while as yet there was no sun-light, one of the fundamental principles of this theory. And it now, consequently, becomes imperative, in continuation, to show the adaptation of *cryptogamous* plants—such as the discoveries of geologists have revealed were the occupiers of the submerged surface of the earth—to the other attendant circumstances of the period alluded to; and, at the same time, to point out the probable uses to which they were applied, in the exercise of their functions, by the all-wise Creator, during the protracted ages which anteceded the formation of the light.

To effect this purpose I shall first direct the attention to part of the *hundred and fifteenth* Theorem, relating to the *fronds* and *imperfect leaves* of the cryptogamous plants, and follow it with a more detailed description of these appendages, in order that their physiological structure and uses may be thoroughly understood.

"The higher tribes of cryptogamic plants," says Professor Henslow, "contained in the division '*Ductalosæ*' have great expansions, much resembling leaves in their general appearance, and, like them, possessing stomata; but differing from them very considerably in some respects, especially in bearing the fructification upon their surface. These have, therefore, received a distinct appellation, and are called 'fronds;' and that part of a frond which is analogous to the petiole is termed the 'stipes.' . . . . . In several tribes the fronds possess nerves, but in many cases they are composed entirely of cellular tissue. . . . . The lower tribes of cryptogamic plants included in the division '*cellulares*,' are very often homogenous in their structure, and of different degrees of consistencies, from highly gelatinous to tough and leathery. When they consist of a plane membranaceous lamina, as in the *lichens*, this is termed a '*thallus*;' but when more or less branched, the name of frond is retained. They are either terrestrial, aquatic, or marine. Many of them are parasitic, seldom green, and without stomata."†

"In ferns," says Mr. Francis, "the FROND is in its leafy part thin, veiny,

* Theorems, Nos. 44, 118, and 120.

† Botany, in Cab. Cyc. pp. 76—78.

and green. The veins do not extend longitudinally through the leaf in any species, as in the monocotyledons, but diverge in a branched form (dichotomously divided) from the base of the leaf, or from the mid rib; differing, however, from those in dicotyledonous plants in not containing woody fibre, and being uniform in size throughout all their ramifications. . . . . Ferns are several years before they come to maturity, until which their essential characteristics are not always obvious. . . . . . .

"The circinate vernation, or curling up of the unexpanded frond, which prevails in all the dorsal ferns, is almost peculiar to this tribe and two of their allies, namely, the palmæ and the cycadeæ. If the frond is simple, so is the vernation; but when the frond is subdivided, the vernation becomes equally compound, the larger divisions first opening, and, by degrees, the branches, pinnæ, and lobes."*

To these general descriptions of the foliaceous appendages of Cryptogamic plants, I shall add a more particular account of those of each ORDER, from the work, already so often referred to, by Sir William Jackson Hooker :—

FUNGI—In the larger sense of the word, the whole may be considered as *fructification*, since distinct from it there is no stem, there are no branches, no leaves, no frond, and very rarely a simple base.

LICHENS—The *Lichens* bear a closer affinity to the *Fungi* than to any other order. Sometimes they are formed of a simple pulverulent crust or frond; sometimes membranaceous, coriaceous, gelatinous, lobed, and variously branched; at all times destitute of leaves.

ALGÆ—Fronds are either gelatinous, filamentous, membranaceous, or coriaceous.

CHARACEÆ—*Stems* slender, confervoid, tubular throughout, pellucid or covered with a calcareous crust, very brittle when dry, and generally fœtid, branched; branchlets whorled, often aculeated. Walloth has given a most admirable account of the fructification of this curious tribe of plants, from which it appears evident that it has no claims to be ranked among the perfect plants, and that its nearest affinity is with the *Confervæ* and *Ulvæ* among the *Algæ*.

HEPATICÆ—*Minute plants* frequently frondose, sometimes (as in *Jungermannia*) foliferous; the leaves often divided, never really nerved.

MUSCI—Bearing leaves which are very rarely indeed divided, often nerved, entire, or toothed, or serrated at the margin.

FILICES—There is, usually, a subterraneous horizontal *stem* or *caudex*. *Fronds*, before expansion, circinate; they are simple and entire, or variously divided and branched, and cut into *lobes* and *segments* or *leaflets*, of various forms. *Substance* varying from membranaceous to coriaceous.

LYCOPODINEÆ—*Leaves* small, undivided, numerous, scattered, or alternate and distichous, often stipulated.

MARSILEACEÆ—'Isoetes.' *Leaves* all radicle, 5—6 inches long, subulate,

* British Ferns, p. 4.

semi-cylindrical, fleshy. 'Pilularia.' Leaves 2—3 inches long, subulate-filiform, clustered.

EQUISETACEÆ—Stems rigid, leafless, jointed, striated, the articulations sheathed at the base; the branches whorled.

NAIADES—Floating herbs with very vascular leaves and stems.*

These extracts demonstrate evidently that we are now occupied with a group of plants whose leafy expansions are relatively imperfect when those of the higher Orders are taken as a standard; and that when they are compared analogically with the respiratory organs of the *testaceous* and *conchiferous mollusca,* a very close analogy is found to exist between them. These latter are defective in pulmonary apparatus, which, in the animal economy, constitutes the point of contact between atmospheric air and the circulating fluids of the higher tribes. The *Cryptogamia* are imperfect in their *foliaceous* appendages, which are the *respiratory* organs of more perfect plants, and the means of communication between *their* circulating system and the surrounding atmosphere; while both, respectively, are provided with modifications of these corresponding organs, in the vegetable and animal existences, well adapted to execute the functions which devolved upon them under analogous circumstances; in either instance differing materially from the duties which the more perfect orders of both kingdoms have now to perform, when the earth has undergone a vast and material change; the modifications alluded to in the construction, and consequently in the functions of the animals and the plants, agreeing admirably with the alteration which, it is maintained, took place about the same period in the material universe.

From a corresponding similarity in the organization respectively which thus prevailed in the animals and plants of *the non-rotating period of the Earth's existence,* there may justly be inferred an analogous object in the design which induced it. This analogy, as a general feature, is very clearly pointed out in a recent standard work on physiology and anatomy.

"The function," say Messrs. Todd and Bowman, "which has for its object the propagation of species, *Generation,* presents many points of resemblance in plants and animals.

"In the former it is cryptogamic or phanogamic; in the latter non-sexual or sexual. In the phanogamic and sexual, the junction of two kinds of matter furnished by the parents is necessary to the development of fertile ova. In the cryptogamic and non-sexual generation, the new individual is developed by a separation of particles from the body of the parent, by which the new formation is nourished only until it has been so far matured as to be capable of an independent existence." . . . . . .

And again—

"In plants there is no nervous system; there is no mental phenomena. The motions of plants correspond in some degree with those movements of animals in which neither consciousness nor nervous influence participate.

* Flora Scotica; also British Ferns, and British Algæ.

Such movements are strictly organic, and result from physical changes produced directly on the part moved."*

In the case of the *Mollusca*, the imperfection of their respiratory organs with respect to that which surrounded them, and a corresponding facility of disposing of inhaled elements *internally*, together with their independence of atmospheric air, was designed—as in reality it was accomplished—to facilitate the formation of carbonate of lime, by abstracting calcium from its combination with other acids possessing a stronger affinity for it than carbonic acid, and constraining these two, through the agency of the molluscous corium, to unite together in due proportions, so as to constitute the innocuous and insoluble material, *carbonate of lime*, whereby the waters not only were purified from, and deprived, to a certain extent, of carbonic acid and of calcium, but the two were safely locked up together in store for future usefulness; becoming first a secure defence to its molluscous inhabitant against the pressure of the surrounding medium, and, eventually, a rocky limestone barrier against the ocean itself, in which it had been formed.

It will be seen, when the plan of argument is farther developed, that the imperfection of the leafy expansions of the *cryptogamia* and their independence of light—the great decomposer of carbonic acid in the vegetable economy—was intended to facilitate, in like manner, the accumulation of *their* peculiar secretions, not only in themselves, but also by their instrumentality, to store up, in the water, elements destined to aid in the formation of the atmosphere, and likewise for more terraine purposes in the sub-soil or strata then forming underneath the primeval ocean. These latter secretions consisted principally of carbon and soda; but were also extended to some others of less general prevalence; while both the solid precipitate and the gaseous exhalation were equally essential for the wants and the comforts of beings to be brought into existence subsequently, and for whose wants the Creator was even then providing with that goodness and forethought which characterize all His plans and arrangements.

My more immediate duty, therefore, at present, is to show *That the imperfect construction of the foliaceous appendages of the Cryptogamia, or of plants resembling them, was designed to produce effects—within the sphere of their action—analogous to those proceeding from the circumscribed and defective respiratory organs of the apulmonic molluscous animals of the same period of the Earth's geological history.* To do this I must again have recourse to the same method which has hitherto been found so successful; although it may be requisite to pursue what may with propriety be called the differential method of reasoning. That is, after having acquired a brief but comprehensive idea of the several divisions of the Vegetable Kingdom, in order to arrive at a knowledge of the functions of those which

* Physiology and Anatomy of Man, vol. i. pp. 25, 27, 28.

existed during the non-rotating period, *and with whose habits and character we can possibly have no direct acquaintance,* I must, first, show the result of an opposite state of matters on plants differently constituted, and then, by inference, deduce the effects likely to have taken place by the action of the imperfectly formed cryptogamia, under the supposed circumstances of the Earth at the time to which I allude; and, by way of confirmation, afterwards compare these deductions with established facts. Having already acquired a knowledge of the principal effects produced on vegetation by the action of the sun's rays, I have now briefly to direct the attention to another result, no less important, which proceeds from the influence of LIGHT.

Dr. Roget, in his Bridgewater Treatise, says—

"An important chemical change is effected on the sap of plants by their leaves when they are subjected to the action of light. It consists in the decomposition of the carbonic acid gas, which is either brought to them by the sap itself, or obtained directly from the atmosphere. In either case its oxygen is separated, and disengaged in the form of gas; while its carbon is retained, and composes an essential ingredient of the altered sap. . . . . .

"It is in the green substance of the leaves alone that this process is conducted: a process which, from the strong analogy that it bears to a similar function in animals, may be considered as the respiration of plants. The effect appears to be proportionate to the number of stomata which the plant contains.* . . . . . Neither the roots, nor the flowers, nor any other part of the plant which have not this green substance at their surface, are capable of decomposing carbonic acid gas. They produce, indeed, an effect which is in some respects the opposite of this; for they have a tendency to absorb oxygen, and to convert it into carbonic acid, by uniting it with the carbon they themselves contain. This is also the case with the leaves themselves whenever they are not under the influence of light.† . . . . .

"The function by which the fluids are thus aerated," according to Messrs. Todd and Bowman, "is called *Respiration.* In plants the introduction of atmospheric air conveys nutriment to the organism; carbonic acid and ammonia are thus introduced; the former is decomposed, its carbon is assimilated, and its oxygen is exchanged for a fresh supply of atmospheric air. As the agent in the decomposition of the carbonic acid is light, it is evident that the generation and the evolution of oxygen can take place only in the day-time. Consequently, during the night, the carbonic acid, with which the fluids of the plant abound, ceases to be decomposed, and is exhaled by the leaves. Hence plants exhale oxygen in the day-time, and carbonic acid at night.‡

"When the food of a plant enters the roots," observes another writer, "it passes upwards, undergoing some chemical change, and dissolving whatever soluble matters it meets with in its course; so that, without having been exposed to any of those conditions by which it is ultimately

* It is worthy of observation that Dr. Roget mentions in a previous page of his work (vol. i.) that stomata are never found in the leaves or stems of submerged plants, nor even on the under surfaces of the leaves of aquatic plants.

† Dr. Roget's Bridgewater Treatise, vol. ii. pp. 29—32.

‡ Physiology and Anatomy of Man, vol. i. p. 24.

and principally affected, it is considerably altered from its original nature before it reaches the leaves.

"It has already been remarked that a portion of the water which plants suck up, combines with the tissue and enters into the general constitution, where it becomes fixed, as the waters of crystalization in minerals. This apparently takes place in the course of the ascent of the sap, before the latter reaches the leaves and becomes exposed to that sort of decomposition and alteration which is here called digestion, and with the phenomena attendant upon which we are best acquainted. . . . . . What we find it most necessary to insist upon in this place, are the three following axioms, to which the experiments of careful observers and skilful reasoners have led:—1. *The quantity of water lost to a plant by evaporation and its power of absorption from the soil, is in proportion to the quantity of Light;* 2. *Light causes a decomposition of the carbonic acid of vegetation; and, consequently, by solidifying the tissue, renders the parts most exposed to it the hardest;* 3. *The digestion of plants chiefly consists in a loss of water by evaporation, and in an acquisition of carbon, by the decomposition of carbonic acid.* . . . . . .

"From these experiments of M. de Candolle it may seem proved that the action of solar light is the great exciting cause of suction at the one end, and of evaporation at the other end of a plant, and that in the night-time plants gain weight, while they lose it in the day-time. Is it not, however, clear that, to speak rigorously, although we may talk of light as being the sole cause of these phenomena—is it not rather the dryness of the atmosphere, caused by the heat of sun-light, as compared with the moisture of the air in the absence of the sun? Thus, in a dry sitting-room, to which the sun has no access, plants undoubtedly perspire by their leaves and absorb by their roots, more than if they were exposed to the sun in a moister atmosphere."*

Professor Henslow also says—

"Light is, as we have seen, the chief agent in stimulating the vital properties of plants, and its effects are apparent in a great number of their phenomena, such as the absorption of the sap, the exhalation of moisture, and the decomposition of carbonic acid."†

The evidences for the *thirty-sixth* Theorem bear particularly upon the point now under consideration; I shall, therefore, direct attention to some of them, although they may have been already referred to: merely observing, as regards the Theorem itself, that it goes to prove, in consequence of the great size of the fossil flora, and magnitude of the fossil shells, that there must have existed where they grew and lived a much higher temperature than even now within the tropics. That it seems to have been alike prevalent everywhere, and that the waters must have contained a greater proportion of carbonic acid than what the seas now do.

"Geologists," observes Sir Henry de la Beche, "have discovered that the superficial temperature of the earth has not always remained the same, and that there is evidence of a very considerable decrease. This evidence rests on the discovery of vegetable and animal remains entombed in situa-

* Botany, in Library of Useful Knowledge, pp. 84, 85.

† Botany, in Cab. Cyc. p. 298. See 44th and 120th Theorems.

tions where, from the want of a congenial temperature, such animals and vegetables would now be unable to exist. Undoubtedly this inference rests on the supposed analogy between animals and vegetables now existing, and those of a similar general structure found in various rocks, and at various depths beneath the earth's surface; but as we now find every animal and vegetable suited to the situations proper for them, we have a right to infer design at all periods, and under every possible state of our earth's surface: and therefore to consider that similarly constituted animals and vegetables have, in general, had similar habitats. . . . . . The vegetable remains are often of considerable size. M. Brongniart observes that in the coal strata of Dortmimd, Essen, and Bochum, stems are found in the planes of the strata more than fifty or sixty feet long, and that they may be traced in some of the galleries for more than forty feet without observing their natural extremities. Vegetables of large size have also been detected in Great Britain. Mr. Witham mentions one in Cragleith quarry as being forty-seven feet in length from the highest part discovered to the root. The bark is described as converted into coal. . . . . .

"According to M. Adolphe Brongniart, if we look at the arborescent ferns and the mass of the other plants, we must consider the vegetation of the carboniferous group to have been produced in climates at least as warm as those of the tropics; and, as we now find plants of the same class increase in size as we advance towards warm latitudes, and as the coal-measure plants exceed the general size of their existing congenors, he concludes with much apparent probability that the climate in which the coal plants existed were even warmer than those of our equinoctial regions."*

Professor Henslow, in treating of the fossil flora of the ancient world, says—

"Judging from analogy, from the character and relative proportions of the species of different classes, the temperature of those parts in which the plants of the first period were growing must have been both hotter and moister than the climates in any part of the earth at present. It has been plausibly conjectured that the atmosphere was more charged with carbonic acid at these early periods of our planet's history, when gigantic species of cryptogamic plants formed the main feature of its vegetation. . . . . Since the fossil plants, which have been found in the arctic regions, are analogous to those which now grow in tropical islands, it seems likely, that not only must they have enjoyed a higher temperature, but also a more equable diffusion of light than those regions now possess."†

The following concurring evidence is from the standard work on Fossil Botany, to which we have already so frequently had occasion to refer:—

"Up to this time"—that of the formation of the lias and oolitic group—"the features of ancient vegetation were exclusively extra European and chiefly tropical; but immediately succeeding the *chalk* a great change occurred, and a decided approach to the flora of modern days took place in some striking particulars. . . . . .

"It is a very remarkable fact that in former ages the range of the species of plants was far more extensive than at the present day. . . . . . M. A.

* Manual of Geology, pp. 6, 429, 431. † Fossil Botany, Cab. Cyc. p. 313.

Brongniart assures us that the plants of the North American coal mines are for the most part perfectly identical with those of Europe, and that they all belong to the same genera; the same is stated of fossils from Greenland and from Baffin's Bay. That ours are very much the same as the rest of Europe is certain.

"And, therefore, a *Fossil Flora* of Great Britain applies not only to the rest of Europe, as might have been expected, but also to very distant countries."*

"Of the decrease in temperature of the Northern hemisphere," observes Mrs. Somerville, "there is abundant evidence in the fossil plants discovered in very high latitudes, which could only have existed in a tropical climate, and which must have grown near the spot where they are found, from the delicacy of their structure, and the perfect state of their preservation. This change of temperature has been erroneously ascribed to an excess in the duration of spring and summer in the Northern hemisphere, in consequence of the eccentricity of the solar ellipse. The length of the seasons varies with the position of the perihelion of the earth's orbit. . . . . . In the present position of the perihelion, spring and summer, North of the Equator, exceed by about eight days the duration of the same seasons south of it. And 10,492 years ago, the southern hemisphere enjoyed the advantage we now possess from the secular variation of the perihelion. Yet Sir John Herschel has shown that by this alteration neither hemisphere requires any excess of light or heat above the other; for, although the earth is nearer to the sun, while moving through that part of its orbit in which the perihelion lies than in the other part, and consequently receives a greater quantity of light and heat, yet, as it moves faster, it is exposed to the heat for a shorter time. In the other part of the orbit, on the contrary, the earth being further from the sun, receives fewer of his rays, but, because its motion is slower, it is exposed to them for a longer time. And as in both cases the quantity of heat and the angular velocity vary exactly in the same proportion, a perfect compensation takes place. So that the eccentricity of the earth's orbit has little or no effect on the temperature corresponding to the difference of the seasons."†

Mr. Lyell says—

"That the climate of the Northern hemisphere has undergone an important change, and that its mean annual temperature must once have resembled that now experienced within the tropics, was the opinion of some of the first naturalists who investigated the contents of ancient strata. Their conjecture became more probable when the shells and corals of the secondary rocks were more carefully examined; for these organic remains were found to be intimately connected by generic affinity with species now living in warmer latitudes. . . . . . When the botanist turned his attention to the specific determination of fossil plants, the evidence acquired the fullest confirmation, for the flora of a country is peculiarly influenced by temperature; and the ancient vegetation of the earth might, more readily than the forms of animals, have afforded conflicting proofs, had the popular theory been without foundation. When the examination of animal and vegetable remains was extended to rocks in the most northern parts of Europe and

* Lindley and Hutton, vol. i. pp. xi. xxiii.

† Connexion of the Sciences, pp. 85, 86. See also 2nd Theorem.

North America, and even to the Arctic regions, indications of the same revolution in climate were discovered."

A little further on he continues—

"We may select the great Carboniferous series, including the transition and mountain limestones, and the coal, as the oldest system of rocks of which the organic remains furnish any decisive evidence as to climate. We have already insisted on the indications which they afford of great heat and uniformity of temperature, extending over a vast area, from about 45° to 60°, or, perhaps, if we include Melville Island, to near 75° North latitude."*

These evidences prove the fact of the general belief entertained, in consequence of the size and other appearances of the vegetable remains, of the universal prevalence of a temperature, in the original ocean, much exceeding that of the present seas; and that, too, for a long but indefinite period, during which, according to this Theory, the Earth was unillumined by the rays of the Sun. All that can be brought forward to explain this seeming anomaly will be carefully adduced in its proper place—meantime it is sufficient for my present purpose to have made evident the prevailing belief, "*That the temperature of the primitive ocean, throughout its whole extent, was as great as that which at present prevails within the tropics, or perhaps greater, and that it contained a larger proportion of carbonic acid gas than is, at present, consistent with animal life.*"

These incontrovertible evidences shut us up into a position from which, at first sight, it appears rather difficult to escape; for by them it has been shown, 1st, That *Light*, *Heat*, and a *moderate* degree of *Moisture* are the essential requisites for the increase of the objects forming the present Vegetable Kingdom. 2nd. That during the formation of the older strata there grew and propagated innumerable gigantic plants; a fact which necessarily implies the simultaneous and abundant prevalence of what are considered the essential requisites for enabling them to do so; while, in opposition to this, although I willingly admit the existence everywhere throughout the strata—as shown by their vestiges—of immense cryptogamic and other allied plants during the period alluded to, I deny the presence of *Sun-light*, maintain the existence of a universal circumfluent ocean, and the presence of considerable surface warmth. The difficulty of escape from this apparent dilemma is not in any degree lessened by an appeal to writers on kindred subjects, for, as a combination of this kind has never been anticipated, very little can be gleaned from their writings bearing directly on the subject. Nevertheless, I must endeavour to grope my way onwards, in the hope that these seemingly conflicting evidences may only be fences which may eventually lead to the truth. What, then, do the assertions which have been made on this subject by botanical writers amount to?

* Principles of Geology, vol. i. pp. 105, 106, 145.

It is stated by one of them—

"That the quantity of water lost to a plant by evaporation, *and its power of absorption from the soil, is in proportion to the quantity of light;*" and "*That the action of solar light is the great exciting cause of suction at the one end, and of evaporation at the other end of a plant.*" Although it is not absolutely denied, "*that these phenomena may not be produced rather by the dryness of the atmosphere, caused by the heat of sun-light, as compared with the moisture of the air in the absence of the sun.*"*

But let the circumstances to which these announcements have reference, and the ends designed to be effected by them, be alike duly considered. They apply to plants growing on Soils, prepared during the lapse of ages for their reception, with depth and consistency sufficient to uphold them throughout every vicissitude of the atmosphere, which contain the requisite salts and other materials for their nourishment, and for enabling them to obtain their full vigour, and to display all their natural attractions. They are, in fact, the conditions of soil, light, and atmospheric elements adapted to form and sustain those beautiful and useful vegetable expansions of the earth's surface; destined, while they attract by every elegance of form, to prepare inert matter for the sustenance and the support of animal and rational life, which, without their intermediate agency in the elaboration of crude matter, would cease to exist. Contemplated in these, which are their true points of view, they manifest the wisdom of the plan which, when such is their design, did place the efficient cause of their absorption, vegetation, and increase, in a luminary far beyond the earth; by which means that which is to be formed—the vegetable substance—is intermediately placed between the source of nutrition and the absorbing power, between the soil and the sun, and surrounded besides by a fostering atmosphere impregnated with elements suitable for assimilation; while the immense proportional distance, by conferring parallelism on the influencing power, the rays of light, causes perpendicularity of position and equality of effect.

These, therefore, *are the attendant conditions of the vegetable kingdom of the present day*, and all the relative circumstances are in perfect harmony with the design for which they were called into being. *They*, consequently, could not have existed under a totally different state of matters, which must be inferred to have prevailed during *the period of non-rotation*. But if the actual vegetable kingdom be, in every respect, suited to the earth, the air, and the sunlight, it is but just to conclude, that the plants of the primeval world, before those conditions existed, would, in like manner, be adapted to their attendant circumstances. If in place of the soil being there for their support and sustenation, it was, itself, to be deposited, they would be independent of it, or, perhaps, instrumental in accumulating it. If there was *no* atmosphere, but, on the con-

* Botany in Lib. of Useful Knowledge, pp. 84, 85, and p. 101 of this work.

trary, a deep surrounding fluid, it is natural to suppose they would not require the former, and be capable of deriving nourishment from the latter; and that while as yet there were no rays of bright sun-light to excite the several functions of air-breathing plants, those that existed in the "darkness" would be wholly indifferent to the sun's enlivening influences.

When we more narrowly scan, with an unbiassed and comprehensive view, what appears, from the revelations afforded by the researches of geologists, to have been taking place at the bottom of the primitive water, while as yet "the Earth was without form and void, and darkness was upon the face of the deep," these anticipations are found to be completely borne out; for if we turn for a moment from the consideration of the Earth and its vegetable covering in their present state of perfection, to enquire whether the same reasoning will hold good, or if the same application of means would have suited, had they been directed to the submarine vegetation of the primeval world, we shall find, with regard to it, that in place of the soil having been perfected for the growth of the plants, these, imperfect as they were, appear to have been the means employed to form the carboniferous deposits, by acting as absorbents on the surrounding medium, and elaborating, by their vegetable chemistry and vitality, the earthy ingredients which the waters held in solution, whereby they contributed towards the formation of the carbonaceous and alkaline deposits by those peculiar secretions which they alone could supply; and, further, by disturbing the equilibrium of the ocean they accelerated the deposition likewise of other earthy matter; and, indeed, that the debris of the strata which they mainly aided to form, has contributed the principal ingredients of the very soil employed at present in cultivation!

Indeed, so concurrent is the prevailing opinion on this point, as regards Algæ, that many seem to think, that plants of this order derive the whole of their nourishment from the water by means of their general surface, the roots serving no other purpose than to attach them to the rocks on which they grow. Or, in some cases, that they are still more independent of their radicle terminations, as the widely extended masses of gulf-weed, a species of *Sargassum*, which, hitherto, has never been found attached by roots.

Those ends having been manifestly held in view, the wisdom and adaptation of the arrangement are made evident by the Creator having ordained that "Darkness should be on the face of the deep;" because "*Light being the great exciting cause of suction at one end of a plant, and of evaporation at another*," Light would have been inimical to the whole scope of the operations then in progress. On the contrary, what was required, and, consequently, that which was in operation, was an influence to stimulate the plants in a direction *opposite* to that in which the sun-light is now known to act upon them, and thereby to occasion an active absorption from the sur-

rounding fluid through their organization, whereby they might appropriate and afterwards assimilate in themselves the nutritious ingredients with which the water was charged; so that in place of nourishment being derived, as it partly is at present, from the soil, it should be abundantly abstracted from the surrounding water, and, by vegetable chemistry, be locked up in the strata, for the future uses and necessities of the world's inhabitants; while the waters themselves should, by the same agency, become simultaneously prepared to perform *their* important part, also, as the seas of the present day.

This view of the case receives confirmation when it is considered, 1st. That there positively did grow in the ancient water gigantic plants, either of the *Cryptogamic orders,* or closely allied to them; the fossil vestiges which remain proving this by the evidence of the senses. 2nd. That these plants could have been in contact with only two distinct substances, or bodies, namely, with the soil and with the water. And 3rd. That they were, themselves, chiefly the means of forming the soil; consequently, as there was little preparatory soil, and the plants are admitted to have grown, and to an immense size, there is no alternative left but to conclude, that as their principal means of subsistence was *not* in the *soil,* it *must have been in the water:* that is, in a degree analogous to the sustenance which plants of the present day derive respectively from the earth and from the atmosphere.

If such was the case (and I hardly know how it can be doubted), there should, on investigation, be discovered a peculiarity of structure in those ancient submarine plants whereby they were adapted to perform their peculiar functions with an effect analogous to what recent trees and plants are enabled to do through their roots and foliaceous appendages. In place of comparatively slender stems and wide-spreading roots to support them in the ground and afford them the requisite nourishment, trees and plants should be discovered with their outer surfaces widened by every possible contrivance, punctured by absorbing apparatus as the means of imbibing from the surrounding waters, with stems, which, in place of spreading out into boughs and branchlets, and being covered with thin and delicate leaves, and decked with flowers, should be less ramified and furnished with other analogous and useful appendages equally well adapted to their native element, and not being subject to the vicissitudes to which trees growing in the atmosphere are exposed by its sudden and violent movements, and which, on that account, are provided with roots to uphold them against the winds—those submarine plants should be furnished with roots much less in proportion to their stems, and by no means so wide-spreading, the still tranquil ocean of the primitive world never exposing its vegetable inhabitants to similar trials, but, on the contrary, sustaining them while they grew, at the bottom of its dark waters, and enabling them to perform *their* part in the development of the plan of creation.

The following extracts confirm this so completely, that, although somewhat long, they cannot properly be omitted :—

"The *Tree-ferns* of the tropical regions exhibit several characters by which they may be compared with the ancient plants dug up from our coal mines. When Dr. Martins saw the first specimens of *Polypodium Corcovadense*, so remarkable for the tesselated surface of its *caudex*, he was struck not only with the novelty of the circumstance, but immediately called to mind the figures of certain petrified forms described by Sternberg under the name of *Lepidodendron;* on comparing which, with the stems of eight arborescent species collected in his journey, he found them connected by so intimate an affinity, that he could entertain no doubts of their generic identity, and was convinced in fact that their characters were perfectly concordant. . . . . . .

"The *Filicites quadrangulatus*, called *palmacites quadrangulatus* by Schlotheim, occurs in the older coal formation, at the coal mines of Opperoda, and Manebach. It corresponds with the stem of the *polypodium corcovadense*. . . . . . . Almost all writers agree in representing the family of *Palms* as having existed among the first vegetables, and as being frequently found buried along with the other fossil remains. Nor is it to be doubted, says Martins, that their remains, viz., the stems, fronds, and fruits, occur in the older coal formation, although they are much less frequent than is commonly believed, the arborescent ferns having been frequently taken for them. . . . . .

"Various genera of *arborescent grasses*, allied to the *Bambusia*, seem to have been much more frequent than palms in our antediluvian plains. To these fossil plants the older writers applied the name of *Calamites*. They are now referred to *Equisetums* by Mons. A. Brongniart. The *Caciphoræ, Dracænæ, Pandani, Yuccæ*, and *Vellosiæ*, constitute another tropical series allied to the palms, which also make their appearance among our primeval plants. The marks by which they may be distinguished are chiefly connected with the circumstance that the stems are invested all round with the semi-amplexicaul base of the leaves which remain after the upper parts have fallen off, and hence they resemble a surface covered with imbricate scales, spirally arranged in various ways, according to the various disposition of the leaves. It appears that the scales being imbricated upwards are not distinct from each other in their whole extent, and therefore may easily be distinguished from the scales of Filicites, so called. . . . . There exist in our coal mines numerous examples of petrified forms, frequently several feet long, remarkable for tubercules or polygonal impressions distinct from each other, and longitudinally disposed in straight lines, separated by parallel grooves or ridges, and marked with a simple cicatrix impressed in the specimen itself upon the carbonaceous bark, but elevated in the impression or cast. These vegetables belong to the genus *Cacti*, all shrubs of warm climates, and are called *Cactites*. . . . . A genus of fossils described by Count Sternberg, under the name of *Syringodendron*, agrees in many of its characters with the *Cactites*, nor can it be doubted that it belongs to the succulent, or fig tribe of vegetables.

"There is a very remarkable fossil, with branches attenuated upwards, and having the whole surface covered with leaf-bearing scales, arranged in an imbricated manner, neither referable to the genus *Yucca* nor to that of *Cactus*, to which Sternberg has given the name *Lepidodendron dichotomum*.

"With regard to this plant, as well as the preceding genera, it deserves to be remarked that, like ferns, they are all vegetables furnished with a singular structure of organs subservient to respiration, and highly adapted for inhaling nutritious juices from the atmosphere. It is well known that the *Cacti* as well as most succulent plants, derive their nourishment more from their relation to the air than to the earth. The *Yuccæ* and *Lychnaphoræ*, which choose for their habitation a dry, sandy soil, that has undergone little preparation from the decomposition of previously existing vegetables, were peculiarly adapted for clothing a recently formed world much warmer than the present. By such plants, vegetable matter would rapidly accumulate to the extent that we find in our coal strata."*

What has now been said, together with the evidences which have been adduced, will be sufficient to show the adaptation of the primeval plants to the primeval condition of the world; and lead to the conviction that only as they then existed could they have fulfilled the object, and wrought out the design of their being. There are still, however, some points to be looked into before this part of the subject can be altogether dismissed. It will be requisite to explain how the decomposition of the carbonic acid and the fixation of the carbon took place; and to show, if possible, what became of that which was not decomposed, and of the other materials which may be supposed to have been imbibed by those plants, deprived, as they were, of sun-light, to cause decomposition and exudation, and stinted, as most of them appear to have been, in foliaceous appendages. This undertaking is by no means easily accomplished; and in attempting it I am met, at the very outset, by rather an imposing difficulty, arising from the seeming incompatibility of some of my positions with admissions which are equally tenable. Not the least formidable of these consists of the following:—

The denial, on the one hand, of the existence of sun-light, the great decomposer and solidifier of ligneous material. On the other, the fact that *Coal* not only is of vegetable origin, but, as appears by the fossil vestiges found intermingled in the formations, that it must have accumulated from plants *which acquired enormous magnitude*, while, at the same time, it is an axiom in Botany, *that the amount of the decomposition of carbonic acid and the fixation of woody matter take place in direct proportion to the quantity of light*; or, as expressed by writers on those subjects, "Light causes decomposition of the carbonic acid of vegetation, and consequently, by solidifying the tissue, renders those plants the hardest which are most exposed to it."†

The only explanation which can be offered, in the present state of information, respecting those arcanæ of the primeval world, is, that the fixation of carbon in forming the woody fibre, having reference principally to that which takes place in the plants of the *Dicotyledonous* and *Monocotyledonous* classes, while the whole scope

* New System of Geology, pp. 445—450.

† Botany in Library of Useful Knowledge, p. 85. See the whole passage included between pp. 85—87.

of my argument rests on the assumption *that the older Coal formations originated in submerged Acotyledons, or plants similar thereto,* it becomes a question, whether these objections, or any that may arise from the ascertained functions of the other two classes, ought to be admitted against the latter, even supposing it to be satisfactorily established that the chemical gradation is uninterrupted between the lignites which proceed from *Monocotyledonous* and *Dicotyledonous* plants, and the coal of the older formation; which latter, although evidently of vegetable origin, yet arose, as has been so frequently insisted upon, from the accumulation of plants whose character and habits show them to have been closely allied to cryptogames, one of whose chief characteristics is indifference to LIGHT.

In following up this subject, therefore, it will be necessary, before making any further enquiries into the disposal of the carbonic acid, and the fixation of the carbon, to ascertain by which part of the vegetable economy the former is considered, by botanical physiologists, to be elaborated.

"The formation of carbonic acid," says Professor Henslow, "takes place in the leaf, beneath the epidermis; but whether the air penetrates through the stomata or not is still uncertain. That it cannot be universally introduced through these organs is apparent, since many leaves have no stomata; and in these cases, at least, the action takes place through the intervention of the delicate membrane, of which the vescicles of the cellular tissue are composed. If a section perpendicular to both surfaces of a leaf be examined under the highest powers of the microscope, the interior will be observed chiefly made up of cellular matter, or 'parenchyma,' whose vescicles are loosely aggregated, so that large intercellular passages exist in communication with each other through its whole substance. That these passages are filled with air is readily shown by placing a leaf under water, and beneath the receiver of an air-pump. Upon exhausting the receiver, the air contained in the leaf will be seen to escape through the petiole: and upon removing the receiver, the water will then find its way into the leaf, and occupy the interstices which were originally filled with air. . . . .

"At present so little has been ascertained of the conditions under which this air has been introduced into the vessels, or of the peculiar office which it is destined to perform, that we can do no more than just mention the fact, and state the opinion of some botanists, who have considered it probable that in these situations also it is subservient to the process of respiration, and who conclude that it is not impossible there may exist a strong analogy between the manner in which this function is performed by plants, and by some of the inferior tribes of animals."*

If, therefore, it be the case that leaves elaborate carbonic acid, it follows, *that the more reduced the size of the leaf, and the more imperfect its structure, the less will be the formation of carbonic acid; and, consequently, the less the necessity of decomposition and exudation.* And, as it has been already shown, from undoubted authority, that the

* Botany in Cab. Cyc. pp. 187, 188.

whole of the Orders and Genera which compose the *Acotyledonous* class of plants are defective in foliaceous appendages, it clearly follows that those operations were by them performed only to a limited extent. In this we enjoy another convincing illustration of the wonderful harmony which prevailed between their conformation and the state of the creation at the period of their existence. *The design was, not to exude, but to retain carbonic acid in the system of the plants*, and, therefore, those appendages, which, by decomposing and exuding this acid, would have frustrated that object to a certain extent, and thereby have proved inimical to the design intended, were very feeble in these vegetable elaborators.

Nor should the idea be overlooked which has been suggested above, "That leaves under the circumstances mentioned, perform the function of vegetable respiration in a manner analogous to that in which the same operation is carried on in the inferior races of animals;" for the establishment of what is thus so unconsciously admitted, or rather conjectured, is the very point sought to be established, as one of the principal steps towards the elucidation of the uses made of those vast forests of submerged Acotyledons, which abounded during the period of darkness and non-rotation.

That the mind may be relieved from any doubt which may arise from the idea that an adequate substitute might have been provided to carry on these operations by other parts of the plants, the following passage is given from the botanical writer to whom we have been already so frequently indebted:—

> "With regard to parts *not* green, which botanists usually call *coloured*, their function seem to be *to absorb oxygen without fixing it, and they appear to possess no power of decomposing carbonic acid when they have formed it*. Such is said to be the case with roots, old trunks, petals, stamens, ripe fruits, mushrooms, and certain lichens. A part of their carbonic acid escapes into the air, a part is dissolved in their fluids, especially in the roots, whence it passes upwards into the system."*

These opinions, given by physiological botanists, of the process by which carbonic acid is decomposed by living plants, and carbonaceous material becomes fixed in the two higher classes, when applied to the case of *Submerged Acotyledons*, would lead us to conclude that taking their deficiency in the operative organs, and the entire absence of the requisite external stimulants into account, they would be found to be remarkable for their paucity of woody fibre throughout the masses of their trunks and branches. The following evidences, taken from the works of geological botanists who have directed their attention to this particular feature of fossil plants, will fully corroborate this assumption:—

EQUISETACEÆ—Reaches from Lapland to the torrid zone. Latitude seems to have had no effect on the size of fossil equisetaceæ. Cala-

* Botany, in Library of Useful Knowledge, p. 90. Confirmed by Dr. Roget's Bridgewater Treatise, vol. ii. p. 32.

mites (Equiseta) characterized by large and simple cylindrical stems.

FILICES OR FERNS—The most numerous of the vascular cryptogamic plants. In the coal measures about 120 known species, forming one-half of the entire known flora of this formation. . . . . The stems of these arborescent ferns are distinguished by certain peculiarities from those of all monocotyledonous plants.

LEPIDODENDRON—With the exception of their great size they very much resemble the *Lycopodiaceæ* or *Club* moss tribe. . . . . . The internal structure of their stems is intermediate between these and *Coniferæ*. . . . . . After *Calamites* the *Lepidodendron* are the most abundant class of fossils in the English coal formations.

SIGILLARIA—Abound most in the transition series. Are colossal. Stems are generally filled with sand or clay, and supposed to have been without any transverse dissepments, and *hollow* throughout. The bark, which alone remains, probably surrounded an axis composed of soft and perishable pulpy matter similar to that of living *Cactæ*. The stems fluted from top to bottom by an external covering, separable like true bark from the soft internal axis, or pulpy trunk; this is usually converted into pure coal. The remaining characteristics of the *Sigillaria* and allied group of fossil plants, *Favularia, Megaphyton, Bothrodendron*, and *Ulodendron*, have been so lately given, that it would be superfluous to repeat them here.

STIGMARIA—Both surfaces of the external rim of the stem are slightly corrugated. Branches covered with spirally disposed tubercules. The form of the trunks and branches show that they could not have risen up into the air, but must have either trailed on the ground or floated in water.*

The following corroborative evidence is taken from the Fossil Flora:—

STIGMARIA—(Variolaria, *Sternb.* Mammillaria, *Ad. Brong.* Ficoidites, *Artis.*) Stem originally succulent, marked with roundish tubercules arranged in a direction more or less spiral; internally a distinct woody axis, communicating with the tubercules by woody processes. Leaves arising from the tubercules, succulent, entire and veinless, except in the centre, where there is some trace of a mid rib.

ASTEROPHYLITES—(Bornia, *Sternb.*) Stem scarcely tumid at the articulations, branched leaves verticillate, linear, acute, single mid rib. (Fruit, a one-seeded (?) ovate compressed nucule, bordered by a membranaceous wing, and emarginate at the apex.) *Brong.*

Note. This is probably an extremely heterogenous assemblage, comprehending nearly all fossils, with narrow veinless verticillate leaves, not united in a cup at their base.

BECHERA—Stem branched, jointed, tumid at the articulations, deeply

* Professor Buckland's Bridgewater Treatise, vol. i. pp. 479—481.

and widely furrowed; leaves verticillate, very narrow, acute, and ribless.

STERNBERGIA—(Columnaria, *Sternb.*) Stem taper, slender, naked, cylindrical, terminating in a cone, marked by transverse furrows, but with no articulations. Slight remains of a fleshy cortical integument.

EQUISETACEÆ and CALAMITES—Stems jointed, regularly and closely furrowed, hollow, divided at articulations by a diaphragm; covered with a thick cortical integument. (? Leaves verticillate, nery narrow, numerous, and simple.)

LYCOPODITES—Branches pinnated. Leaves inserted all round the stem in two opposite rows, not leaving clean and well-defined scars.

LEPIDODENDRON—(Sagenaria, *Sternb.*) Stems dichotomous, covered near extremity with simple linear leaves. Areolæ, &c.

ULODENDRON—Stems covered with rhomboidal areolæ. Scars large, few, one above the other, composed of broad cuneate scales, radiating from a common centre, and indicating the former presence of organs that were perhaps analogous to the cones of Coniferæ.

SIGILLARIA—(Rhytidolepis; Aveolaria; Favularia; Catenaria, &c., *Sternb.*) Stems conical, deeply furrowed, not jointed, scars placed between the furrows in rows, not arranged in a distinctly spiral manner, smooth, much narrower than the intervals which separate them.*

After perusing these evidences it cannot be doubted that the design—which of course was accomplished—was to throw the bulk of the carbonaceous material, which the ancient plants were capable of elaborating, into the exterior rim of their stems and branches.

The element in which they floated would, while it supplied them with nutriment, very materially contribute to this by upholding their pulpy or semi-hollow bulky trunks, and permitting them to send forth their spirally arranged branches in every direction around them.† The whole arrangements respecting these ancient plants—existing as they did at so early a period of the Earth's history—exhibit another fine example of the admirable adaptation of means to an end which characterises all the handiworks of the Omnipotent.

The evident intention having been to create carbonaceous matter by means of the periphery of these huge vascular plants, there was no element by which they could have been better upheld than water,

* Fossil Flora, by Lindley and Hutton, vol. i.

† I consider the spiral arrangement of their branches, leaves, and fronds, or cones, which seems to have been general, very strong presumptive evidence of their having floated in water. It is asserted of the *stigmaria* that they either did so, or "*trailed on the ground.*" Had this latter been their habit, would their branches have proceeded in regular order *all round the stems?* Would not the spiral arrangement have been interrupted wherever the trunk rested on the ground? It is maintained from their debility, in comparison with their great size and length, that they must have done the one or the other—the attendant circumstances are adverse to one of the suppositions—that of trailing on the ground; but are in strict accordance with the other. Can there, therefore, be any doubt as to which opinion should be ultimately adopted?

and there is no imaginable form better calculated to confer strength upon, and to increase the extent of the external surface of any cylindrical body whatever than by fluting, that is, by forming it into ridges and depressions parallel to the line of its axis; nor is there any other construction which would enable a plant, in contact with a surrounding fluid from which it was deriving nourishment and support, more effectually to be supplied with both. And, in the instance in question, these means, it is found, were effectually adopted.

There may also be discovered, what, with all deference, may be called a degree of mannerism in these arrangements.

In the case of the molluscous and zoophytic agency the object then was to create carbonate of lime for the beneficent purposes intended, and this was effected by causing the innumerable forms of these creatures to encrust themselves with ponderous coatings of that stony material.

In the instance now more immediately under consideration, the design seems to have been to create carbonaceous matter (and perhaps to form free oxygen), by an agency in the vegetable world corresponding to the imperfect molluscs of the animal kingdom; and, in carrying this into execution, the plants were caused to secrete carbonaceous matter throughout the whole extent of their comparatively rigid exterior around a soft and vascular central axis; whereby it is to be assumed that the greatest amount of the destined material could be elaborated in the least possible time, while it conferred relatively the greatest degree of strength to the stems themselves.

In continuation of this part of the argument, it may be remarked, that there is reason to suppose that plants possess the power of throwing off, by their roots, whatever may have entered into their circulation which is hurtful to them. On this point the following quotations are very conclusive:—

"That roots give off, in some cases, a peculiar matter, has been known for some time. Brugmans was the first to observe it in the heartsease; and it was afterwards remarked in the elm and some other plants. No one, however, seems to have suspected this to be a general function of vegetation before M. de Candolle, who as long ago as the year 1805, called attention to this curious subject. It now appears from experiments conducted by M. Macaire, of Geneva, that to throw off excretions by the roots is a general property of plants, and one of their most important vital actions. . . . . . The faculty, indeed, which plants possess of getting rid of excretions by the roots would seem to be a necessary condition of their life; for if they had not such a power, the fæcal matter which they now part with would be re-dissolved by the ascending sap, and carried back into their system to their own destruction. Macaire showed by a simple experiment that a plant if poisoned will disembarrass itself of the offending matter by its roots, if it has the opportunity. He took a plant of Mercury *(Mercurialis Annua)*, and divided its roots into two parcels, one of which he introduced

into a weak solution of acetate of lead, and the other parcel into pure water; at the end of a few hours, the water which was originally pure had become imperceptibly impregnated with acetate of lead, which had therefore been taken into the circulation by the roots on one side of the plant, and thrown off again by the roots on the other."*

Dr. Roget, in his Bridgewater Treatise, affords the following confirmatory evidence:—

"It had long been conjectured by De Candolle, that the noxious particles contained in the returning sap of plants, are excreted or thrown out by the roots. . . . . . The truth of this sagacious conjecture has been established in a very satisfactory manner by the recent experiments of M. Macaire,† by which he 'ascertained that neither the roots nor the stems of the plants he employed when completely detached and immersed in water could produce this effect,' which he therefore concludes is the result of an exudation from the roots continually going on while the plant is in a state of healthy vegetation.

"By comparative experiments on the quantity of matter thus excreted by the roots of the *Phaseolus Vulgaris*, or French bean, during the night and the day, he found it to be much more considerable at night; an effect which it is natural to ascribe to the interruption in the action of the leaves when they are deprived of light, and when the corresponding absorption by the roots is also suspended. This was confirmed by the result of some experiments he made on the same plants by placing them during the day time in the dark, under which circumstances the excretion from the roots was found to be immediately much augmented. . . . . .

"The same fact was also proved by another set of experiments on the *Mercurialis Annua*, the *Seneui Vulgaris*, and the *Brassica Campestris*. The roots of each specimen, after being thoroughly cleaned, were separated into two bunches, one of which was put into a diluted solution of acetate of lead, and the other into pure water in a separate vessel. After some days . . . . the water in the latter vessel was found to contain a very perceptible quantity of acetate of lead. . . . . . Similar experiments were made with lime water, and with a solution of common salt, and were attended with like results. De Candolle has ascertained that certain maritime plants which yield soda, and which flourish in situations very distant from the coast, provided they occasionally receive breezes from the sea, communicate a saline impregnation to the soil in their immediate vicinity, derived from the salt which they doubtless had imbibed by their leaves."‡

It now only requires to be ascertained *whether plants which are denied the sun-light contain more carbonic acid than those which enjoy its rays; and if aquatic plants actually deposit carbonic acid from their roots;* and, fortunately, both these points have been established beyond the possibility of a doubt, as will be seen by the following quotations:—

Mr. Murray, writing to the Edinburgh Philosophical Journal, says—

* Botany, in Library of Useful Knowledge, pp. 104, 105.

† For an account of these experiments see the fifth volume of the "Memoire de la Societe de Physique, &c., de Geneve,"

‡ Dr. Roget's Bridgewater Treatise, vol. ii. pp. 45—50.

"While in London, last winter, I made a considerable number of experiments on the hyacinth, &c., growing in bulb glasses; the bulb being carefully washed with distilled water, was seated on the glass filled also with distilled water, and the whole covered with a bell glass. In two or three days the water was highly saturated with carbonic acid gas, and this being precipitated with lime-water, potassa, or caustic barryta, afforded a brisk effervescence on the affusion of diluted acid. The immediate *milkiness* which ensued on agitating the fluid with lime-water, was proof enough, though it was well to carry the experiment to its ultimatum. In numerous repetitions I found it uniform, and showed it to some of my friends.

"By using lime-water much diluted with distilled water, the interior surface and bottom of the bulb glass were incrusted with minute rhombs of carbonate of lime, perfectly diaphanous.

"From a seedsman in Fleet Street I got a bulb and bulb glass; the roots had already shot down fibres into the water four or five inches long, and it was fast advancing into flower. The fibres of this plant when I received it were ragged at the tips, and tingent or gaping, and they were also quite transparent. Water had filled these tubes, and given rise to a beautiful phenomenon; for the descent of the air-bells was thus exhibited, and closed the evidence, if further proof had been necessary.

"This fact will certainly tend to explain some apparent anomalies. In experiments made on plants in relation to their amelioration of the atmosphere, contaminated by respiration, wherein no beneficial change [or a bad one] was exhibited, it must be evident that, as carbonic acid is excreted by the roots, the confined atmosphere might be deteriorated by the gas arising from the earth when the soil in which the vegetable grows is saturated. Besides, these experiments may change our views in relation to the phenomena of agriculture, while it will satisfactorily explain the prompt transit of caustic earths into carbonates; and thus may be a hint valuable even to the *geologist*."*

On consulting any work on chemistry, it will be ascertained that the *Algæ* produce soda and potash combined with carbonic, sulphuric, and muriatic acids; and it has been seen by the remarks of Dr. Roget that marine plants deposit saline substances when placed in circumstances favourable for doing so.

The following direct testimony corroborative of these facts, from a different source, will, no doubt, be perused with interest:—

"In a commercial point of view," says Dr. Landsborough, "our British sea-weeds rise in national importance on account of *kelp*, which is made from them. . . . . . When M'Culloch visited the Hebrides, in 1818, the total product of kelp from these islands was estimated at 6,000 tons, which at £20 per ton, must have realized the sum of £120,000. . . . . We shall pass over the method of making the kelp from *Laminævia digitata*, *Fucus serratus*, *Nodosus*, &c., and follow the *material* to Glasgow, where there are at present twenty establishments, some of them very extensive, for the *lixiviation* of kelp, and the manufacture, from it, of iodine, &c. . . . . .

"The object of the *lixiviator*, as he is called, is to separate the various salts which the kelp contains. The most insoluble are those which are

* Letter by Mr. Murray, in Edinburgh Philosophical Journal, No. xiv. pp. 329, 330.

first separated, consisting of the *sulphate of potash*, the *carbonate, muriate, and sulphate of soda*, and the *muriate of potash*.

"The most soluble remain in the solution. In the solution the *iodine* and other very soluble salts are found, and it is from them the liquor, called the *mother liquor*, that *iodine* is extracted."*

With this satisfactory testimony I close the evidences for this part of the subject, and proceed to sum up what has been said during the present chapter.

This branch of our general subject has been followed through all its windings, until we have reached a point which establishes the fact, that it is a property common to plants to throw off by their roots whatever might otherwise be prejudicial for them to retain; that they likewise deposit carbonic acid by their roots, or accumulate it within themselves when deficient in those radicle appendages; and that some of the cryptogamic plants produce carbonate, muriate, and sulphate of soda, and of potash. These evidences corroborate, to a certain extent, the assumption that the elaboration of carbonaceous matter and the storing of it up for future purposes in certain forms, together with the deposition of some of the stratified masses, were within the scope, and appear to have been the principal objects contemplated, and fully accomplished, by the submerged vegetation during the non-rotating period of the primitive world. Indeed, we have only to take into account the inexhaustible stores of carbonaceous matter which exist in the great coal formations, the large proportion of carbon which enters into the composition of almost all vegetable soils, and the volume of carbonic acid locked up [to be released at pleasure] in the extensive calcareous formations which everywhere abound, to be convinced of the amount of work performed during that protracted period by the instrumentality of vegetable chemistry, the plants which performed it being immersed in the waters of the primeval ocean, whilst "the earth was without form and void, and darkness was upon the face of the deep."

The evident and close adaptation of means to the end, which is recognised in all these arrangements, evinces, in the most undeniable manner, that no other class of plants, *except one which does not correspond with the description of either of those given in the first chapter of Genesis*, could then have existed; for, if any other could have performed the work required, they would have been there associated with the ancient flora; while, in another respect, there is a perfect accordance between this state of matters in the primeval world, and the announcements made by the inspired historian, who, evidently being cognizant of this fact, omitted to enumerate the *flowerless, seedless, fruitless* plants, when putting on record the creation of the other two perfect classes.† The knowledge of this also

* History of British Algæ, pp. 60, 61.

† I beg to be clearly understood: I mean by this all plants not included in the description given, namely, "The herb yielding seed, and the fruit-tree yielding fruit, whose seed is in itself upon the Earth," each after their respective kinds.

clearly points to the alone source from whence it could have been derived.

Nothing, perhaps, tends more to corroborate the view we have adopted of the *entirely distinct eras* of the creation of the *flowerless, seedless, fruitless,* and of the *phanogamous* plants, than the contrast which is afforded by a comparison between the well-authenticated restriction of the *recent* Flora, of more perfect construction, to foci of creation treated of so much in what is called *botanical geography;* and the universality and equality of the wide-spread and everywhere abounding *cryptogames* of the primeval world. The former, affected by the divergent inequalities of the earth's surface, kept apart from each other, as it were, by insular and continental distances, and bearing the stamp of differences of climate and of soil. The comprehensive command applicable to the whole terraine surface, "Let the Earth produce grass," having, by its climatic zones, been modified into perfect adaptation to each, and thereby having caused distinct foci of vegetation amongst the phanogamous classes. The primeval flora, seemingly indifferent to all these influencing causes, found embedded everywhere, and everywhere alike, so that in the language of M. de la Beche, "there certainly was a similar vegetation about the same period over parts of Europe and North America, which leads to the inference that there was a similar climate over a large portion of the northern hemisphere, such as we have not at present, for it was at least tropical, if not ultra-tropical;" and this Messrs. Lindley and Hutton fully corroborate when they offer the following cogent reasons as a general recommendation of their admirable work, the Fossil Flora:—

"In another point of view, we think," say they, "a work of this kind is likely to be of general utility. It is a remarkable fact, that in former ages the range of the species of plants was far more extensive than at the present day. The plants of the North American coal mines are, for the most part, perfectly identical with those of Europe; they all belong to the same genera. The same is the case with fossils from Greenland and from Baffin's Bay. Ours are very much the same as those of the rest of Europe, and, therefore, a Fossil Flora of Great Britain applies not only to Europe generally, but also to very distant countries."

And, altogether, warrants the belief, that one set of effects are produced by the *phanogamous* plants having been created *after* the Earth had assumed its actual diversity of form, and present vicissitudes of climate, while another and an altogether different set of effects arose from the no less certain cause of the earth having, when the ancient flora existed, been *a sphere of non-rotation, surrounded by a dark and atmosphereless ocean,* where no difference of climate or change of season were ever known; but being one vast range of level surface, under the same omnipotent and fostering care, the plants now found fossil were equally produced wherever necessary over its whole extent; nurtured until they assumed their

indicated magnitude, and caused to perform important offices in the formation of the strata, and in the purification of the waters.

With these observations I shall bring this section to a close; believing that what is contained in it has advanced us another step towards the unfolding of the prefatory assumption, "*That during the period referred to, there were being formed, under the primitive ocean, by the combined instrumentality of chemical and electrical agency, and of animal and vegetable secretion, those materials which were afterwards, when raised from their recumbent position by centrifugal impetus, to constitute an important part of the earth's geological formations and meteorological phenomena, while, simultaneously, the ocean was undergoing due preparation for becoming the seas of the present time.*"

SECTION III.

DEPOSITION OF THE STRATA DURING THE NON-ROTATORY PERIOD.

CHAPTER VIII.

The subject of argument of the present Section succinctly stated. Deposition of the stratified masses. Proof that the materials which compose the strata existed in the primeval ocean. The Earth accurately weighed before the deposition commenced, and after it ceased, and found, in either case, to be the same. In continuation, several sources of doubt respecting the origin of the strata removed, and clearly shown that underneath the stratified masses of the Earth's crust there is an impervious base of amorphous crystalline rock. Order of superposition laid down, in accordance with the classification of M. de la Beche. Table given, and corroborated by general extracts. Wherever the surface of the Earth has been geologically examined, it is found to have been, at one time submerged in the waters of the ocean. And, in conclusion of this chapter, that all stratified rocks afford evidence of having been deposited from water.

HAVING shown, in the preceding Sections, that there existed in the primitive ocean, before "the separation of the waters and the dry land," successive tribes of creatures and of plants which were made use of to secrete the peculiar ingredients necessary alike for the meteorological elements and for the perfection of the stratified masses, it now becomes necessary to endeavour to elucidate the manner in which it is considered that these strata were deposited from the ocean in which the inferior animals and plants were thus engaged, while fulfilling their appropriate destinies. To relieve the argument from all unnecessary complication, no direct allusion shall be made, for the present, either to the Conglomerates and Breccias, nor to the Unstratified Formations—under pledge of resuming those points hereafter. The attention will be principally directed to the deposition of the strata, with only such occasional allusions to the others as are indispensable.

The first step to be taken in this inquiry is to become assured *that the materials which contributed to the formation of the strata actually did exist in the water then surrounding the nucleus of the Earth;* for, unless we are convinced of this, all the reasoning which may be founded hereafter on its assumption, will be uncertain and inconclusive, while, on the other hand, if established, as I trust it will be, the future argument will be greatly confirmed and strengthened.

Let it, then, be supposed, that, before any deposition whatever took place, the whole Earth was accurately weighed, and the weight noted down; that, after a lapse of ages, the examination of its sur-

face displays certain concentric layers of strata surrounding it in every direction, bearing evident symptoms of having been deposited from a fluid which had held them in solution and suspension; that we should be assured the greatest part of these did not derive their origin either from the comminution or the disintegration of other rocks; that we should be made aware of the existence *underneath* the secondary strata of a continuous hard shell or crust, from *within* which the strata could not possibly have come; and that there should now be an immense body of water, clear and pellucid, containing little or no earthy matter, washing those stratified masses in their upheaved position; and then let it be further supposed that the terraqueous globe, after all these changes had taken place in both of its portions, was again placed in the same balance, and found to have neither lost nor gained a single apice in weight; that it remained precisely the same as it was at first; it would seem natural and just to infer therefrom, *that the materials of the stratified masses* DID *exist in the turbid primeval waters, from whence they were deposited, leaving them pellucid and sparkling as they now are;* and it shall be my care to show that all these presumed circumstances are correct, and capable of bearing whatever superstructure may be raised upon them.

It will be observed by the *seventieth* Theorem, *that the law of gravitation is in direct proportion to the mass, and inversely as the square of the distance.* It is stated by an accomplished writer on this subject to be

"A singular result of the simplicity of the laws of nature, which admit only of the observation and comparison of ratios, that the gravitation and theory of the motions of the celestial bodies are independent of their absolute magnitudes and distances. Consequently, if all the bodies of the solar system, their mutual distances, and their velocities, were to diminish proportionally, they would describe curves in all respects similar to those in which they now move; and the system might be successively reduced to the smallest sensible dimensions, and still exhibit the same appearances."*

The same writer further states that

"In the midst of all the vicissitudes which affect the solar system, the length of the major axes and the mean motions of the planets remain permanently independent of secular changes. They are so connected by Kepler's law, of the squares of the periodic times being proportional to the cubes of the mean distances of the planets from the sun, that one cannot vary without affecting the other. And it is proved that any variations which do take place are transient, and depend only on the relative positions of the bodies."†

This truth was previously borne ample testimony to by Professor Playfair, who, with his usual elegance of language, says—

"La Grange found, by a method peculiar to himself, and independent of any approximation, that the inequality produced by the mutual action of

* Connection of the Sciences, p. 408. † Ibid, p. 25.

the planets must, in effect, be all periodical: that amidst all the changes which arise from their mutual action, two things remain perpetually the same, viz., the length of the greater axis of the ellipse which the planet describes, and its periodical time round the sun, or, which is the same thing, the mean distance of each planet from the sun, and its mean motion, remain constant. The plane of the orbit varies, the species of the ellipse and its eccentricity change; but never, by any means whatever, the greater axis of the ellipse, or the time of the entire revolution of the planet.

"The discovery of this great principle, which we may consider as the bulwark that secures the stability of our system, and excludes all access to confusion and disorder, must render the name of La Grange for ever memorable in science, and ever revered by those who delight in the contemplation of whatever is excellent and sublime."*

A recent writer on Astronomy, in a work of some celebrity, says—

"I have already shown how the permanence of the orbit of each planet depends upon the perfect balance of two forces or tendencies, viz., the attractive power of the sun, and that tendency to fly from the centre which follows from the motion of bodies being naturally in straight lines, and whose energy depends in each case upon the rapidity of the body's motion. If the power of either of these balanced forces be diminished, it is clear that the authority of the other will prevail. Relax gravity, therefore, and the planet will recede from the sun, and its orbit will widen until a balance is restored. In the same manner, diminish the rapidity of the body's motion, and as the centrifugal force will be diminished by the same act, gravity will prevail, so that the body's orbit will be contracted or drawn in."†

When we have to bring forward evidences from the resources of the exact sciences, the matter is very soon concluded. These three quotations equally confirm, and completely so, the first and last assumptions with which I commenced; because, before the laws which are mentioned in them could have been established, the relative mass of the earth, with respect to the sun and other bodies of the system, must have been determined with unnerring precision; and, consequently, whatever that was, at the most remote period to which astronomical calculations have any reference, it must be the same at this moment; for, as the earth's mean distance from the sun is invariable, and the law of gravitation exacts a proportional increase or diminution of the mass, should the distance be enlarged or reduced, it follows as an axiom, *that as the distance has remained the same, the mass or weight must also have remained without change.*

The next point to be disposed of, is, to prevent any subterfuge being sought in the belief that the secondary strata owe their origin to the comminution or disintegration of pre-existing rocks. The fundamental assumption in this argument, namely, the non-rotation of the earth during the period of the deposition of the stratified

* Review of Laplace, Mecanique Celeste, Playfair's Works, vol. iv. p. 289.
† Nichol's Architecture of the Heavens, p. 152.

masses, is so inseparably connected with the dogma of its having been then a sphere of level surface, bounded by a circumfluent ocean, that the possibility of disintegration from previously-existing rocky mountains is so incompatible with these that they must either stand or fall together. The change in the *position* of the primary and stratified masses will be explained in its proper place; but in the meantime, I beg that the horizontallity of the whole earth during that epoch may be allowed; and considered to be a sufficient explanation for the absence of disintegration. Although this may, perhaps, be considered an extreme request by those who are accustomed to witness the primary rocks forming the highest points in almost all mountain ranges, and the secondary ones tilted up, and hanging on their shoulders, yet, when it is considered that it has been adopted as a geological axiom, *that these rocks have been moved through a certain space into their present positions,* the intervening space may, as fairly, be considered to have been from *horizontality* as from any intermediate inclination; and the more so, as their elevation from a *perfect level* can be proved, although I should shrink from the task, if a less static position were imperatively demanded as that of their original starting point.

This brings me to examine into the truth of the only remaining unproved postulate, namely, the existence *underneath* the secondary strata of a boundary line of impenetrable rocks, forming a continuous shell or crust, from *within* which the stratified masses could not possibly have come; and here, before proceeding with any proof, I feel disposed to use the words of Dr. M'Culloch, and say—

"It is our object to trace the disposition of the rocky surface of the globe, from the most distant or early point at which the marks of change are perceptible, and to pursue its changes down to the present day. Beyond that distant point it is possible that there may have been other changes; but of these we can find no evidence. A curtain is here drawn to separate the visible world from that which is, to us, as if it had never existed. That this system had a beginning, we are certain; where that may lie, we know not; but for us it is placed beyond that era at which we can no longer trace the marks of a change of order, of the destruction and renovation of its form. It is from this point that a theory of the earth must commence; it is from this also that the present enquiry begins."*

There is even a higher authority for laying this restriction upon our enquiries. The inspired historian himself in his narrative takes up the Creation as the light found it; and from that eventful period only enters into particulars. I assume the Earth to have been without inequalities of form, and bearing upon its rocky level surface a shoreless circumfluent ocean. He narrates that "the Earth was without form and void," while, availing myself of what he was made the chosen instrument to reveal, carrying it back, as it were, by the differential method, I apply it and endeavour to fathom the

* Geology, vol. i. p. 462.

dark and atmosphereless "abyss of waters;" which circumbounded it in the beginning.

Admitting the deposition of the stratified masses to have been from a fluid holding them in suspension and combination, which is not attempted to be denied, then it follows as a matter of course, *that there must have been an under surface of rocks, of some* DESCRIPTION OR OTHER, *which formed the ground-work or base on which the universal menstruum was sustained, while those strata were being deposited from it.*

This general view of the case will be strengthened when it is considered that it is contrary to the laws of matter to suppose that the original water could have been the matrix of all the rocky materials constituting the solid nucleus of the earth. This would involve the double absurdity of supposing that the containing water increased as the solid nucleus increased, and experienced a corresponding augmentation of earthy sediment in proportion to the increasing demand for deposition. But, entertaining little fear that such tenets as these will be brought forward and sustained, while, on the other hand, the fact of "the strata having been deposited tranquilly in a horizontal position from water holding them in combination,"* is never for a moment doubted, we are shut up to the conclusion that, at whatever geological period it may have occurred, there assuredly was, at one time, a solid surface around and all over our earth impervious to water, on which the primeval ocean rested, while from it were being deposited those successive layers of different kinds which constitute the whole of the older and part of the more recent strata; while the animal and vegetable remains found interwoven in these† prove beyond the possibility of a doubt, that the water, however different from the seas of the present day, was capable of sustaining the creatures and plants to which those exuviæ belonged.

The existence of such a universal base is fully admitted by geologists, in all their writings on the subject.‡ Indeed, so much so, that in another part of this work, the general conclusion has been come to, "That the granitic, trappean, and serpentinous classes of rocks, with their immediate associates, form the nucleii of all mountain ranges; that there is a strong analogy between granite, trap, and porphyry; and that their common origin must be sought for in nearly the same source, and from the same cause."§ A few illustrations bearing on these conclusions may be satisfactory before this part of our subject is closed.

"Assuming," says Professor Buckland, "that fire and water have been the two great agents employed in reducing the surface of the globe to its actual condition, we see in the repeated operations of these agents, causes adequate to the production of those irregular elevations and depressions of the fundamental rocks of the granitic series, which are delineated in the

* 13th and 14th Theorems. † Theorems 16 and 19. ‡ Theorem 21.
§ Theorems 25, 26, and 27.

lower region of our system, as forming the base of the entire superstructure of stratified rocks."*

Mr. Lyell states that

"If we investigate a large portion of a continent which contains within it a lofty mountain range, we rarely fail to discover another class, very distinct from either of these alluded to, and which we can neither assimilate to deposits such as are now accumulated in lakes or seas, nor to those generated by ordinary volcanic action. The class alluded to consists of granite, granitic schist, roofing slate, and many other rocks, of a much more compact and crystalline texture than the sedimentary and volcanic divisions before-mentioned. In the unstratified portion of these crystalline rocks, as in the granite, for example, no organic fossil remains have ever been discovered. . . . . . .

"These remarkable formations have been called *primitive*, from being supposed to constitute the most ancient mineral productions known to us, and from a notion that they originated before the earth was inhabited by living beings, and while yet the planet was in a nascent state. Their high relative antiquity is indisputable; for, in the oldest sedimentary strata, containing organic remains, we often meet with rounded pebbles of the older crystalline rocks, which must, therefore, have been consolidated before the derivative strata were formed out of their ruins. They rise up from beneath the rocks of mechanical origin, entering into the structure of lofty mountains, so as to constitute, at the same time, the lowest and most elevated portions of the crust of the globe.† . . . . .

"It would be easy," continues the same writer, "to multiply examples to prove that the granitic and trap rocks pass into each other, and are merely different forms which the same elements have assumed, according to the different circumstances under which they have consolidated from a state of fusion. What we have said respecting the mode of explaining the different textures of the central and external parts of the Vesuvian dykes may enable the reader, in some measure, to comprehend how such differences may originate."‡

"It is," says Dr. M'Culloch, "in the deeper regions of the globe, therefore, in those where we have found the origin of granite, that we must seek that of trap. These substances are essentially of the same nature, but they have been produced at distant periods of time. . . . . .

"I am unable to perceive that anything is wanting to prove the identity of origin in trap and granite. It is little likely, at least, that geology will often furnish us with evidence of a more decided nature. Nor is it an indispensable requisite to this argument to produce numerous examples; since there are innumerable cases in science, among which this seems one, where one or two facts are as decisive as a hundred."§

"Notwithstanding its inferiority in position," continues the same author, "we must not grant, as asserted, that granite constitutes the mass of the globe, or is the lowest rock in existence. Of its interior we know nothing; but its weight is sufficient to prove that it is not formed of granite. . . . . Some unstratified matter, solid or fluid, does, doubtless, lie beneath the stratified surface of the earth; but while conjectures are fruitless, it might, if solid, be basalt, as well as granite.

* Bridgewater Treatise, vol. ii. p. 3. † Principles of Geology, vol. iii. pp. 10—13.
‡ Ibid, vol. iii. p. 36. § Geology, by Dr. M'Culloch, vol. i. p. 148, et seq.

"Though treating of it first in order, it is plain that it is not so viewed here; while I need not re-discuss the relations of the stratified to the unstratified rocks. It is sufficient that granite disturbs the former, transmits veins through them, and affects their mineral characters; while the strata do not follow it in that regular order in which they succeed each other; but are variously and confusedly placed with regard to it, so that a single mass may touch all the members of one series—a property not possessed by any stratum. This is posteriority, but it is a posteriority only where the fact of intrusion is thus proved. Rocks have been deposited on it, as I shall immediately show; and in examining the revolutions of the earth, I have rendered it probable that there has been granite, or an analogous substance, prior to all strata, and the original source of the whole."*

Professor Phillips asserts

"*Inferiorly*, the primary strata rest on unstratified, generally granitic rocks, so situated as to cut off all possibility of observation at greater depths. This granite floor—this universal crystalline basis to all the stratified rocks—appears, in many instances, to have undergone fusion since the deposition of the strata upon it. . . . . . . It is enough for our present purpose to recognise the general truth of the stratified rocks, which are the products of water, resting universally on unstratified crystalline rocks, which, through whatever previous conditions their particles may have passed, have assumed their present characters from the agency of heat. Igneous rocks then rest below all the aqueous deposits."†

The last postulate, namely, that the earth was re-weighed after deposition, and found to be precisely the same as before, having been already proved, I shall consider that, with the concurring extracts just given, the case is closed in favour of the point so important to be established, namely, *that the materials which compose the strata of the secondary and part of the tertiary formations, were at one time contained in the water which surrounded the globe during its period of non-rotation;* and having thus prepared the mind, by freeing it from all bias to the contrary opinion, I shall be the better able to fix upon some admitted order of superposition, from the oldest stratified formation up to the magnesian limestone; as it is indispensably necessary to adopt and to follow out some one geological classification.

"To propose," oberves Sir Henry de la Beche, "in the present state of geological science, any classification of rocks which should pretend to more than temporary utility, would be to assume a more intimate acquaintance with the earth's crust than we possess. Our knowledge of this structure is far from extensive, and principally confined to portions of Europe. Still, however, a mass of information has gradually been collected, particularly as respects this quarter of the world, tending to contain general and important conclusions, among which the principal are—that rocks may be divided into two great classes, the stratified and the unstratified; that of the former some contain organic remains, and others do not; and that the non-fossiliferous stratified rocks, as a mass, occupy an inferior place to the fossiliferous strata, also taken as a mass. The next important conclusion is, that among

* Geology, by Dr. M'Culloch, vol. ii. pp. 87, 88.

† Treatise on Geology, pp. 69, 70.

the stratified fossiliferous rocks, there is a certain order of superposition, apparently marked by peculiar general accumulations of organic remains, though the mineralogical character varies materially. . . . . . .

"Classifications of rock should be convenient, suited to the state of science, and as free as possible from a leading theory. The usual divisions of primary, transition, secondary, and tertiary, may, perhaps, be convenient, but they certainly cannot lay claim to either equality with the state of science, or freedom from theory."*

As it is intended, amidst the prevailing diversity of nomenclatures and classifications, to adopt that of Sir H. de la Beche, his table of comparative classification is opportunely annexed, to assist in leading us through the difficulties which will assuredly present themselves.†

* Geology, by Sir H. T. de la Beche, pp. 32, 33.

† Manual of Geology, pp. 38, 39. See also the very comprehensive Table, No. 2, given by Mr. Lyell, in his work, vol. iii. pp. 389—393.

CLASSIFICATION OF ROCKS IN A DESCENDING SERIES.

			Improved Wernerian.	Conybeare.	Omalius d'Halloy, 1830.		Brongniart, 1829.	
STRATIFIED ROCKS. Superior stratified, or fossiliferous.	1. Modern Group	Detritus of various kinds produced by causes now in action; coral islands, travertino, &c.	Alluvion	Superior Order.	Tertiary rocks.	Secondary.	. . . . Alluvial and Lysian rocks .	Jovian period.
	2. Erratic Block Group . . .	Transported boulders and blocks; gravels on hills and plains, apparently produced by greater forces than those now in action.	Diluvium; Ancient Alluvion.				. . . . Clysmian rocks.	
	3. Supercretaceous Group .	Various deposits above the chalk, such as in England, the Crag, Isle of Wight beds, London and plastic clays. In France, the freshwater and marine rocks of Paris, &c.	Tertiary				Izemian rocks.	Saturnian period.
	4. Cretaceous Group	1. Chalk. 2. Upper green sand. 3. Gault. 4. Lower green sand. To which may be added for convenience, 1. Weald clay. 2. Hastings sands. 3. Purbeck beds.	Secondary.	Supermedial Order.	Ammonean rocks.			
	5. Oolitic Group	The rocks usually known as the oolite formation, including the lias.						
	6. Red Sandstone Group	1. Variegated or red marl. 2. Muschelkalk. 3. Red sandstone. 4. Zechstein. 5. Red conglomerate.						
	7. Carboniferous Group	1. Coal measures. 2. Carboniferous limestone. 3. Old red sandstone.	. . . .	Medial Order.	. . . .		Hemilysian rocks	
	8. Grauwacke Group	Grauwacke, thick-bedded, and schistose, sometimes red; grauwacke limestones; grauwacke clay slates, &c.	Transition.	Submedial Order.	Hemilysian rocks	Primordial.		
	9. Lowest Fossiliferous Group .	Various slates, frequently mixed with stratified compounds, resembling those of the unstratified rocks.	. . . .		. . . .		Agalysian rocks.	
Inferior stratified, or non-fossiliferous.	No determinate order of superposition	Various schistose rocks, and many crystalline stratified compounds, such as gneiss, protogine, &c.	Primitive, or Primary.	Inferior Order.	. . . .			
Unstratified rocks.	Volcanic, Trappean, Serpentinous, and Granitic rocks	Ancient and modern lava, trachyte, basalt, greenstone, corneans, augite and hornblende porphyries, serpentine, diallage rock, sienite, quartziferous porphyry, granite, &c	Arranged among the stratified rocks according to the order in which they are supposed to occur.	The same as the improved Wernerian.	Pyroidal and Agalysian rocks.		Modern volcanic rocks classed as pyrogenous rocks; igneous rocks of an older date, as Typhonian.	

"The greater part of our continents," says Mr. Lyell, "are evidently composed of subaqueous deposits; and in the manner of their arrangement we discover many characters precisely similar to what has been described; but the different groups of strata are, for the most part, on a greater scale, both in regard to depth and area, than in any observable in the new formations of lakes, deltas, or estuaries. We find, for example, beds of limestone several hundred feet in thickness, containing embedded corals and shells, stretching from one country to another, yet always giving place, at length, to a distinct set of strata, which either rise up from under it like the rocks before alluded to as forming the borders of a lake, or cover and conceal it. In other places, we find beds of pebbles and sand, or of clay of great thickness. The different formations composed of these materials usually contain some peculiar organic remains; as, for example, certain species of shells and corals, or certain plants. . . . . .

"All the subaqueous strata which we before alluded to as overlying the primary, were at first called *secondary;* and when they had been found divisible into different groups, characterized by certain organic remains and mineral peculiarities, the relative position of these groups became a matter of high interest. It was soon found that the order of succession was never inverted, although the different formations were not co-extensively distributed; so that if there be four different formations, as *a, b, c, d,* which in certain localities may be seen in vertical superposition, the uppermost or nearest of them, *a,* will in other places be in contact with *c,* or with the lowest of the whole series, *d,* all the intermediate formations being absent."*

"The great bulk of the accessible surface of the solid earth," observes Dr. M'Culloch, "is composed of stratified rocks, which, under different modes of distribution, form not only the low plains, but the elevated mountains; being brought into view by their irregularities of position, and by that denudation which so often laid them bare, and has generated the lower materials which, in other parts, conceal them from immediate examination. . . . . . .

"The term stratum, or bed, carries its own definition with it; its extent, according to the prolongation of its great opposing planes, being generally far greater than its thickness. A repetition of such beds forms a series of strata; and the term stratification implies the mode of their deposition, to whatever cause that may be attributed. . . . . . . The term stratification, therefore, implies a cause, as well as a mode of form and disposition; and that cause is assumed, or proved, to consist in a deposition from water, of materials that have been suspended and dissolved in it."†

It will now be necessary to adduce some of the innumerable proofs which exist in favour of the *thirteenth* Theorem, "*That wherever any considerable portion of the earth's surface has been examined by geologists, it has invariably afforded proofs of having been at one time submerged in the water of the ocean.*"

"A very little attention," Professor Playfair remarks, in his Illustrations of the Huttonian Theory, "to the phenomena of the mineral kingdom, is sufficient to convince us, that the condition of the earth's surface has not

* Principles of Geology, vol. iii. pp. 9—15.
† Geology, by Dr. M'Culloch, vol. i. pp. 61, 67.

been the same at all times as at present. When we observe the impressions of plants in the heart of the hardest rocks; when we discover trees converted into flint, and entire beds of limestone or of marble composed of shells and corals; we see the same individual in two states—the most widely different from one another; and in the latter instance, have a clear proof, that the present land was once deeply immersed under the waters of the ocean."*

"The lowest and most level parts of the earth," M. Cuvier asserts in his Theory, "when penetrated to a very great depth, exhibit nothing but horizontal strata composed of various substances, and containing almost all of them innumerable marine productions. Similar strata, with the same kind of productions, compose the hills even to a great height. Sometimes the shells are so numerous as to constitute the entire body of the stratum. They are almost everywhere in such a perfect state of preservation that even the smallest of them retain their most delicate parts, their sharpest ridges, and their finest and most tender processes.

"They are found in elevations far above the level of every part of the ocean, and in places to which the sea could not be conveyed by any existing cause. They are not only enclosed in loose sand, but are often encrusted and penetrated on all sides by the hardest stones. Every part of the earth, every hemisphere, every continent, every island of any size, exhibits the same phenomenon. We are therefore forcibly led to believe, not only that the sea has at one period or another covered all our plains, but that it must have remained there for a long time, and in a state of tranquillity; which circumstance was necessary for the formation of deposits so extensive, so thick, in part so solid, and containing exuviæ so perfectly preserved."†

"Geologists," Sir John Herschell states, "now no longer bewilder their imaginations with wild theories of the formation of the globe from chaos, or its passage through a series of hypothetical transformations, but rather aim at a careful and accurate examination of the records of its former state, which they find indelibly impressed on the great features of its actual surface, and to the evidence of former life and habitation which organized remains embedded and preserved in its strata indisputably afford.

"Records of this kind are neither few nor vague, and though the obsoleteness of their language, when we endeavour to interpret it too minutely, may, and no doubt often does, lead to misapprehension, still its general meaning is, on the whole, unequivocal and satisfactory. Such records teach us, in terms too plain to be misunderstood, that the whole, or nearly the whole, of our present lands and continents were formerly at the bottom of the sea, where they received deposits of materials from the wearing and degradation of other lands not now existing, and furnished receptacles for the remains of marine animals and plants inhabiting the ocean above them, as well as for similar spoils of the land washed down into its bosom."‡

"Calcareous rocks," says Mr. Lyell, "containing the same class of organic remains as our transition and mountain limestones, extend over a great part of the central and northern parts of Europe, are found in the lake districts of North America, and even appear to occur in great abundance as far as the border of the Arctic sea. The organic remains of these rocks consist

* Playfair's Works, vol. i. p. 19.
† Cuvier's Theory of the Earth, by Professor Jamieson, pp. 7, 8.
‡ Natural Philosophy, in Cab. Cyc. pp. 282, 283.

principally of marine shells, corals, and the teeth and bones of fish; and their nature, as well as the continuity of the calcareous beds of homogeneous mineral composition, concur to prove, that the whole series was formed in a deep and expansive ocean, in the midst of which, however, there were many isles." . . . . . .

Again—

"A glance at the best geological maps now constructed of various countries in the northern hemisphere, whether in North America or Europe, will satisfy the enquirer, that the greater part of the present land has been raised from the deep, either between the period of the deposition of the chalk and that of the strata termed tertiary, or at subsequent periods, during which various tertiary groups were formed in succession. For, as the secondary rocks, from the lias to the chalk inclusive, are, with a few unimportant exceptions, marine, it follows that every district now occupied by them has been converted into land since they originated."*

Evidences so unanimous and so conclusive leave not a doubt, that, "wherever the earth's surface has been examined to any extent, it affords undeniable proofs of having been formed at the bottom of the ocean." The importance of this demonstration, however, cannot be fully appreciated until it has been shown, that there was *only one general elevation* of the strata; and, consequently, that the stratified masses which afford such perfect evidence of their submarine origin, *must have been so situated at one and the same time;* while the circumstance of their having been simultaneously covered by the ocean, proves alike that the earth must, of necessity, have been a sphere without rotatory motion; for no other form could fulfil all the conditions required, when the comparative shallowness of the ocean is taken into account;† and the impossibility of this ever covering the earth's surface after the first revolution around its axis had occasioned those great inequalities, which, at present, distinguish its geographical outlines. Without dwelling longer, however, on this great truth for the present, but resting satisfied with having shown that wherever any considerable area of the earth's surface has been accessible to geological examination, it affords the clearest possible evidence of having been formed beneath the water of the ocean, I shall next proceed to give some equally conclusive quotations in support of the first part of the *fourteenth* Theorem, in which it is asserted *that the stratified rocks afford suffi-*

* Principles of Geology, vol. i. pp. 146, 155.

† Sir H. T. de la Beche considers the ocean to be only two miles in mean depth, and his evidence on this point is so apposite that I cannot avoid giving it:—"The depth of the ocean has been variously estimated at between two and three miles. The mean height of the dry land above the ocean level does not exceed two miles. Therefore, assuming two miles for the depth of the ocean, the waters occupying three-fourths of the Earth's surface, the present dry land might be distributed over the bottom of the ocean in such a manner that the surface of the Earth would present a mass of waters—an important possibility, for with it at command, every variety of the superficial distribution of land and water may be imagined; and consequently every variety of organic life, each suited to the various situations and climates under which it would be placed."—*Manual of Geology*, pp. 2, 3.

cient evidence of having been formed in succession, horizontally and tranquilly, by deposition from water.

"It is well known," says Dr. Hutton's accomplished illustrator, "that on removing the loose material which forms the immediate surface of the earth, we come to the solid rock, of which a great proportion is found to be regularly disposed in strata, or beds of determinate thickness, inclined at different angles to the horizon; but separated from one another by equidistant superfices, that often maintain their parallelism to a great extent. These strata bear such evident marks of being deposited by water, that they are universally acknowledged to have their origin at the bottom of the sea; and it is also admitted that the materials of which they consist were then either soft, or in such a state of comminution and separation as rendered them capable of arrangement by the action of the water in which they were immersed. Thus far most of the theories of the earth agree: but from this point they begin to diverge, and each to assume a character and direction peculiar to itself. . . . . .

" . . . . . The materials of the strata are disposed, as we have already seen, loose and unconnected, at the bottom of the sea; that is, even on the most moderate estimation, at the depth of several miles under its surface. . . . . . .

"Now, it is certain that many of the strata have been moved angularly; because that, in their original position, they must have been all nearly horizontal. Loose materials, such as sand and gravel, subsiding at the bottom of the sea and having their interstices filled with water, possess a kind of fluidity; they are disposed to yield on the side opposite to that where the pressure is greatest, and are, therefore, in some degree, subject to the laws of hydrostatics. On this account they will arrange themselves in horizontal layers; and the vibrations of the incumbent fluid, by impressing a slight motion, backward and forward, on the materials of these layers, will very much assist the accuracy of their level. . . . . .

"Now, rocks having their layers exactly parallel, are very common, and prove their original horizontality to have been more precise than we could venture to conclude from analogy alone. In beds of sandstone, for instance, nothing is more frequent than to see the thin layers of sand separated from one another by layers still finer of coaly or micaceous matter, that are almost exactly parallel, and continue so to a great extent without any sensible deviation.

"These planes can have acquired their parallelism only in consequence of the property of water just stated, by which it renders the surfaces of the layers which it deposits parallel to its own surface, and therefore parallel to one another. Though such strata, therefore, may not now be horizontal, they must have been so originally, otherwise it is impossible to discover any cause for their parallelism, or any rule by which it can have been produced.*

"For more than two centuries," says Mr. Lyell, when reasoning on the *unphilosophical assumption of the discordance of the ancient and existing causes of change*, "the shelly strata of the sub-appenine hills afforded matter of speculation to the early geologists of Italy, and few of them had any suspicion that similar deposits were then forming in the neighbouring sea. . . . . . . Some imagined that the strata, so rich in organic remains, instead

* Playfair's Huttonian Theory, pp. 4, 44—46.

of being due to secondary agents, had been so created in the beginning of things by the fiat of the Almighty; and others ascribed the imbedded fossil bodies to some plastic power which resided in the earth in the early ages of the world. At length Donati explored the bed of the Adriatic, and found the closest resemblance between the new deposits there forming, and those which constituted hills above a thousand feet high in various parts of the peninsula. He ascertained that certain genera of living testacea were grouped together at the bottom of the sea in precisely the same manner as were their fossil analogies in the strata of the hills, and that some species were common in the recent and fossil world. Beds of shells, moreover, in the Adriatic, were becoming incrusted with calcareous rock, and others were recently inclosed in deposits of sand and clay, precisely as fossil shells were found in the hills. . . . . . .

" . . . . . It must always have been evident to unbiassed minds, that successive strata, containing, in regular order of superposition, distinct beds of shells and corals, arranged in families as they grow at the bottom of the sea, could only have been formed by slow and insensible degrees in the lapse of ages; yet, until organic remains were minutely examined and specifically determined, it was rarely possible to prove that the series of deposits met with in one country was not formed simultaneously with that found in another. But we are now able to determine, in numerous instances, the relative dates of sedimentary rocks in distant regions, and to show by their organic remains that they were not of contemporary origin, but formed in succession. We often find that where an interruption in the consecutive formations in one district is indicated by a sudden transition from one assemblage of fossil species to another, the chasm is filled up, in some other district, by other important groups of strata."*

While referring to the table given of the classification of rocks, by Sir H. T. de la Beche, by which the great portion of the stratified, and, consequently, the deposited ones, will at once be recognized, I consider it opportune to subjoin the following detached quotation from his Manual, in which, it will be observed, he assumes the stratified masses to be established as deposits, and treats of them as such by inference:—

"Having premised this much," he says, "respecting the geographical distribution of the cretaceous group, we will take a slight sketch of the variations in its mineralogical character. Throughout the British Islands, a large part of France, many parts of Germany, in Poland, Sweden, and in various parts of Russia, there would appear to have been certain causes in operation, at a given period, which produced nearly, or very nearly, the same effects.

"The variation in the lower portion of the deposit seems merely to consist in the absence or presence of a greater or less abundance of clays or sands, substances which we may consider as produced by the destruction of previously existing land, and as deposited from waters which held such detritus in mechanical suspension. The unequal deposit of the two kinds of matter in different situations would be in accordance with such a supposition. But when we turn to the higher part of the group into which the lower portion graduates, the theory of mere transport appears opposed to

* Principles of Geology, vol. i. pp. 96—99.

the phenomena observed, which seem rather to have been produced by deposit from a chemical solution of carbonate of lime and silex covering a considerable area. . . . . .

"When we view the oolitic group as a whole, such as it occurs over a considerable portion of Western Europe, we cannot but be struck with the general uniformity of its structure. The three great argillo-calcareous deposits alternate with as many that are calcareous or arenaceous, but principally the former. When we attempt to apply the operation of such causes as those we daily witness in explanation of this uniformity, we seem to involve ourselves in innumerable difficulties, though to explain certain minor appearances they may be useful. . . . . In a general view of this deposit it would seem better to consider it in connection with the succeeding group. As joined with it, it appears the upper part of one great mass which has been deposited in various inequalities of surface, the superior portion frequently overlapping the inferior part, so that it rests directly on the older rocks," and so forth.

"The red sandstone group succeeds in the descending order. . . . . The rocks composing this group occur in the following descending order: 1. Variegated Marls; 2. Muschel Chalk; 3. Red or Variegated Sandstones; 4. Zechstein; and 5. Red Conglomerate, or Todtliegendes. . . . . .

"The coal measures are composed of various beds of sandstone, shale, and coal, irregularly interstratified, and, in some countries, intermixed. They abound in vegetable remains, and the coal itself is now, by very general consent, referred to a vegetable origin, being considered the accumulation of an immense mass of plants. . . . . By general consent the coal is considered as resulting from the distribution of a body of vegetable remains over areas of greater or less extent, upon a previously deposited surface of sand, argillaceous silt or mud, but principally the latter, now compressed into shale.

"After the distribution of the vegetables, other sands, silt, or mud, were accumulated upon them. . . . . Great length of time would be requisite for this accumulation, because the phenomena observed would lead us to consider the transporting power, though variable, to have been generally moderate; moreover, a very considerable growth of vegetables requiring time would be necessary at distinct intervals; for coal beds now only six or ten feet thick, must, before pressure was exerted upon them, have occupied a much greater depth. . . . . .

"It has been observed that the old red sandstone of some countries graduates into grauwacke, whence it may be inferred that the causes, whatever they may have been, which produced the latter deposit, were not violently interrupted in such situations, but that they were gradually modified. . . . . . .

"If the size of transported substances be considered as the necessary evidence of rapid currents of water, the grauwacke rocks, taken as a mass, have been slowly deposited; for, though evidences of cross currents are sufficiently abundant in the various directions of the laminæ, and in the mode in which arenaceous and slaty beds are associated with each other, the substances are generally fine grained, rarely passing into conglomerates. . . . . There is, however, a general appearance in the mass of the grauwacke which would lead us rather to consider a great portion of it of slow deposition. . . . . .

"The grauwacke group occurs in Norway, Sweden, and Russia. It forms a portion of Southern Scotland, whence it ranges, with breaks formed by newer deposits or the sea, down Western England into Normandy and Brittany. It appears abundantly in Ireland. A large mass of it is exposed in the district constituting the Ardennes, the Eifel, the Westerwauld, and the Taurus. Another mass constitutes a large portion of the Hartz mountains, while smaller patches emerge in other parts of Germany, on the north of Magdeburg, and other places. In all these situations there is, notwithstanding small variations, a general and prevailing mineralogical character, which points to a common mode of formation over a considerable area.

"From all the accounts, also, that have been presented to us by Dr. Bigsby and other American geologists, we have every reason to consider that a deposit closely agreeing in relative antiquity, and in its general mineralogical and zoological characters, exists extensively in North America: so that there is evidence, also, to show that some general causes were in operation over a large portion of the northern hemisphere, and that the result was the production of a thick and extensive deposit, enveloping animals of similar organic structure over a considerable surface. . . . . .

"We have now arrived," says the same intelligent geologist, "at that early condition of our planet when, as far as our knowledge extends, neither animal nor vegetable life existed on its surface. . . . . .

"The inferior stratified rocks are of various compositions, sometimes so passing into each other that it is almost impossible to affix definite names to the different mixtures.

"It would be tedious to enumerate the various situations where these inferior stratified rocks may be found; it will suffice to state, that there is scarcely any large extent of country where, from some accident or other, they are not exposed on the surface. They abound in Norway, Sweden, and Northern Russia; they are common in the north of Scotland, whence they stretch over into Ireland. In the Alps and some other mountains, they occupy the central lines of elevation, as if brought to light by the movements which have thrown up the different chains. They abound in the Brazils, and occur extensively in the United States. Our navigators have shown that they are sufficiently common in the various remote parts of North America visited by them. They are found extensively in the great range of Himalaya. Ceylon is in a great measure composed of them; and they do not appear to be scarce in various other parts of Asia.

"In Africa, also, we know that they are not wanting, though but so small a part of that continent has been yet explored with scientific views. Hence we may consider that whatever may be the nature of the deposits on which we stand, such strata exist beneath us, unless in cases where masses of igneous rocks have, by protrusion, forced them asunder, and left no stratified substances intermediate between the surface and the interior of the globe."*

A geologist, who has written more recently, expresses his opinion, as far as the Old Red Sandstone group is concerned, in the following graphic manner, with which I shall close this part of the evidence:—

"The geologists of the school of Werner," says he, "used to illustrate

* Manual of Geology, by Sir H. T. de la Beche.

what we may term the anatomy of the Earth, as seen through the spectacles of their system, by an onion and its coats. They represented the globe as a central nucleus, encircled by concentric coverings, each covering constituting a geological formation. The onion, through the introduction of a better school, has become obsolete as an illustration, but to restore it again, though for another purpose, we have merely to cut it through the middle, and turn downwards the plane formed by the knife. It then represents, with its coats, two such hills as we describe—hills such as Ben Nevis, ere the granite had perforated the gneiss, or the porphyry broken through the granite."

After pointing out, in another passage, how unsafe it is to calculate the depth of deposits by the altitude of hills, or to estimate the correctness of the calculations made in one district by those which may have been made in some other widely separated locality, he states—

"So enormous is the depth of the deposit (the red sandstone) in Caithness, that it has been deemed by very superior geologists to represent three entire formations:—the Old Red system, by its unfossiliferous, arenaceous, and conglomerate beds; the Carboniferous system, by its dark-coloured middle schists, abounding in bitumen and ichthyolites; and the New Red Sandstone, by its mottled marls and mouldering sandstones that overlie the whole;" and which unitedly, "in some localities attain a depth fully equal to the elevation of Mount Etna over the level of the sea."*

* Old Red Sandstone, by Miller, Edinburgh, pp. 60, 61, 52.

SECTION III.

DEPOSITION OF THE STRATA DURING THE NON-ROTATORY PERIOD.

CHAPTER IX.

Further inferences respecting the existence of the elements of the strata in the primitive ocean; and of the crystaline base on which they universally repose. Attendant circumstances of the Earth in perfect accordance with the work of deposition then going on. Character and component elements of the lower stratified, or non-fossiliferous rocks, given with the design of showing that their elements existed in the primitive menstruum. Endeavours to describe the process by which these elements were abstracted from the water with which they were thus combined. The immediate influence of the luni-solar current exemplified by the theory of the tides. Geological construction of the non-fossiliferous rocks —confusedly crystaline. Their specific gravity given, and the influence of attraction in their formation. Aqueous crystalization, and the predominating influence which it exercised at this early stage of the creation. Capacity of water for becoming chemically impregnated with mineral elements shown and corroborated by the waters of Carlsbad, and other mineral springs. Chemical affinity; its universality and influence. Brief summary in conclusion of this, as a preparation for succeeding Chapters.

The copious and concurring extracts which have been given in the preceding chapter sufficiently prove the deposition from water of the stratified rocks which now constitute a great portion of the solid crust of the earth. They also bear testimony to the fact, that those successive layers rest upon a base of unstratified material, from *within* which they could not possibly have come.

The sphericity of the earth's surface, which has been premised, precludes it from being supposed that the strata owe their origin to the disintegration of pre-existing rocks; while it has been shown by a combination of fundamental astronomical laws, that no increase of the weight or gravity of the globe took place since its creation; and that the only addition made to it was the principle of organic life in the inferior animal and vegetable existences which were then brought into being; but as this living principle added not one iota to the gravity of the sphere, I have a right to conclude, as the result of these well-sustained premises, *that the elements of the strata which formed part of the weight of the Earth at the beginning, were contained in the circumfluent ocean; and were deposited from it.* But it must be here observed, that it was not alone by the separation of the mineral parts, by *deposition*, that the primeval water became the pellucid seas of the present day; the gaseous elements of the atmosphere were, by combination with the principle of light, when

formed, made to *ascend* from the water, and, by their abstraction, also to purify and leave the ocean what it now is. If it be admitted, therefore, that the ponderous earthy masses were, on the one hand, taken by precipitation from the primitive water, and that the volatilized gaseous elements were made to rise out of them, on the other —all having originally been contained *in* the water when "the Earth was without form and void, and darkness was upon the face of the deep"—surely, without departing in the slightest degree from philosophical reasoning, or asking too much, it may be demanded, for argument's sake, that they may be considered for a short time to be restored to them; while the non-existence of the atmosphere will render this concession, as far as regards the gaseous elements, all the more easily granted. And it having been shown, by the writings of geologists, that the strata now rest upon a base of unstratified rocks, we may safely consider, that the water, which held the elements of the strata in its grasp, rested, before these were deposited, *on that on which the deposited matter now reposes;* while to complete the proper conception of the condition of our planet at the remote period to which I allude, we have only to imagine it, thus geologically constituted, to be without rotatory motion, but circulating with the same velocity in the identical orbit through darkened space, wherein it now travels around the illumined sun.

If there be anything, more than another, which I desire to avoid in conducting this work, it is that of assuming any unnecessary or unfounded supposition as the base line of subsequent conclusions. *I assume nothing but what can be proved by well-sustained evidence in the sequel.* Our senses evidence to us undoubtedly that the Earth at present rotates, is illumined by the sun, and is beautifully diversified by hill and dale, and by the greater inequalities of continental ridges and oceanic hollows. Yet, in asking my readers to imagine that the world which they now inhabit—if eyes there had been to behold it—would have presented to the vision a shoreless abyss of dark and atmosphereless water, devoid of rotatory motion, and deprived of the soul-cheering rays of the sun, I do no more than truth dictates to me; *for this was its actual condition for many ages.* It is thus first of all presented to our notice in the Sacred Volume, wherein it is announced that "the Earth was without form and void; darkness was upon the face of the deep, and the spirit of God moved upon the face of the waters."

If this revealed description be believed in, and its non-rotation conceded for a short time, I feel confident of being able *to prove that it did not rotate for a long but indefinite period,* and that it was then in the dark and atmosphereless condition to which allusion has so frequently been made.

To be assured that the attendant conditions of the Earth were in accordance with perfect wisdom, I purpose to enquire, whether the spherical form of the globe, surrounded by an illimitable ocean of

equal depth, was not better adapted for promoting the deposition of earthy matter from a fluid, than the relative distribution of land and water, with unequal depths, and reduced aqueous surface, which at present constitute its geographical features; and whether, under any possible circumstances, and at any period, the sea could have covered the whole sphere.

To do this, reference will be made to the *first* Theorem, in which it is stated, "*That a sphere is that form which contains the greatest volume of all bodies of equal surface.*" This, applied to the case under consideration, assures us that a sphere is that form capable of containing the greatest possible mass of matter within a given quantity of water, and to permit this last to maintain the greatest possible depth while it circumbounds the contained solid mass. In this state the globe and its aqueous envelope are conceived to have remained during the entire period of non-rotation. By referring to the *eighth* Theorem, it will be observed, that the aqueous portion of the earth's present surface is to the terrestrial part as *three* to *one*, or nearly so; i. e. only three-fourths of superfice is now covered by the same water which formerly circumbounded its whole extent; and if, from the *first* Theorem, there be taken the diameter of the Earth, we shall soon discover what a vast area that is, and how admirably adapted the surface then was for favouring deposition from a fluid holding matter in suspension; while, if it be considered that the most moderate estimate makes the mean depth of the ocean two miles, others considering it between four and five, and that the average of mountains is only two miles above the level of the sea—the greater portion of the earth's surface having but a very limited elevation above that level—no doubt will remain as to the possibility, under the premised conditions of the globe, of the water of the ocean having covered the whole surface of a non-rotating sphere; thereby more fitly adapting it for the gradual deposition of the earthy matter contained in the circumfluent water.* Thus we acquire, by every additional step in the investigation, increasing evidences of the infinite wisdom which directed the whole plan of creation.

I have next, in the prosecution of this laborious research, to set forth the nature and component parts of the *stratified rocks* throughout the series which are supposed to have been thus deposited, and enquire into some of the causes then in operation which contributed to their formation.

The inferior stratified or non-fossiliferous rocks, according to Sir Henry de la Beche, consist of

"1. Clay; 2. Aluminous Slate; 3. Whetstone Slate; 4. Flinty Slate; 5. Chloride Slate; 6. Talcose Slate; 7. Steachiste, Hornblende Slate; 8. Hornblende Rock; 9. Quartz Rock; 10. Serpentine; 11. Diallage Rock;

* See note at page 131.

12. Whitestone; 13. Mica Slate; 14. Gneiss; and 15. Protogine; with respect to which he remarks—

"Although the above are the most remarkable of the inferior stratified rocks, they are far from being the whole of them. The varieties and transitions of one to the other appear endless, and, occurring in no determinate order, set classification utterly at defiance. . . . . . .

"If we consider what minerals have entered most largely into the composition of the whole mass, we find that quartz, felspar, mica, and hornblende are those with which it most abounds, and which impress their characters upon its various portions. Chlorite, talk, and carbonate of lime are certainly not wanting; but if we, as it were, withdraw ourselves from the earth and look down upon such parts of its surface as are geologically known, we find that these latter mineral substances constitute a very small portion of the whole. The inferior stratified rocks, which form the largest part of the exposed surface of our planet, are gneiss and micah slate, and when viewed on the great scale the others are more or less subordinate to them.

"Supposing this view an approximation to the truth, we arrive at another and important conclusion, namely, that the minerals which compose the mass of these stratified rocks are precisely those which constitute the mass of the unstratified rocks—rocks which, from the phenomena attending them, are referred to an igneous origin. . . . . We find, still viewing the subject in the mass, that the same elementary substances have produced the same minerals in both, the only difference between them being their general difference of arrangement relatively to each other, so that they should constitute a stratified compound in the one case, and not in the other.

"Viewed on the large scale, the grauwacke series consists of a large stratified mass of arenaceous and slaty rocks intermingled with patches of limestone, which are often continuous for considerable distances. The arenaceous and slate beds, considered generally, bear evident marks of mechanical origin, but that of the included limestones may be more questionable. The arenaceous rocks occur both in thick and schistose beds; the latter state being frequently owing to the presence of mica disposed in the lines of the laminæ. Their mineralogical character varies materially; and while they sometimes, though rarely, pass into a conglomerate, they very frequently graduate into slates, which become of so fine a texture as to lose the arenaceous character altogether. Roofing slate is not rare among the grauwacke rocks; and if we consider it of mechanical origin, like the mass of the strata among which it is included, we must suppose it to have originated from the deposition of a highly comminuted detritus.

"The coal measures," according to the same geologist, "are composed of various beds of sandstone, shale, and coal, irregularly interstratified, and in some countries intermixed with conglomerates; the whole showing a mechanical origin.

"The old red sandstone is of very variable thickness, sometimes consisting of a few conglomerate beds, while at others it swells out to the depth of several thousand feet. . . . . . . The sandstone possesses different degrees of induration, and is not unfrequently schistose and micaceous. The conglomerates of course vary in their contents, but pieces of quartz are very common."*

* Manual of Geology, by Sir H. T. de la Beche.

Should further and corroborative evidence be required on this essential point, the reader may refer to the detailed and elaborate tables which are given by Mr. Lyell, in his "Elements of Geology," which although, in some cases, compiled more immediately from the analysis of rocks composing the older formations, may on the whole be taken as exhibiting pretty nearly the constituent principles of the others also:—

"Chemical science," says Dr. Ure, "demonstrates that the crust of the earth consists mainly of six substances, Silica, or the matter of rock crystal, Alumina, or pure clay, Iron, Lime, Magnesia, and Potash. Silica, in the crystaline form, is called quartz, and is a large constitutent of the primitive mountains, granite, gneiss, and mica slate. . . . . The third of the primitive stratified rocks is clay slate or roofing slate. If to these four bodies, namely, quartz, felspar, mica, and clay slate [called simple materials, because they are of homogeneous aspect], we add hornblende and augite, we shall have before us the principal mineral constituents of the primitive shell of the globe. . . . . .

"Thus we see that silica, clay, lime, magnesia, iron oxide, and potash, constitute by far the greater portion of the hard materials of the earth, as far as it has been explored."*

The following table of the Older Stratified Rocks, taken from the same work, will show the components of the same series, viz.:—

Class I.	Primitive, or Inferior Rocks.	Concomitants.
Order I.	Gneiss	Granites, Hornblende rocks, Limestones, Quartz rocks
" II.	Mica	As above, Gypsum.
" III.	Clay Slate	Mica slate, Talk slate, Chlorite slate, Gneiss, Whet slate, Alum slate, Dolomite, Gypsum.
Class II.	Transition, or Submedial Rocks.	
Order I.	Grauwacke . . .	Conglomerate, Clay slate, Flinty slate, Alum slate, Limestone, Dolomite, with Encrimites.
Class III.	Medial, or Carboniferous Rocks.	
Order I.	Old Red Sandstone.	
,, II.	Carboniferous or Mountain Limestone.	
,, III.	Millstone Grit, or Shale.	
" IV.	Coal Measures .	Coal Sandstone, Slaty clay, Bituminous shale, Carbonate of iron, Coal, Calcareous marl, Alpine limestone.†

At present I shall only enumerate four of the groups which per-

* Geology, pp. 89, 90. † New System of Geology, pp. 131, 132.

tain to the *secondary* rocks, the others not being immediately connected with this part of the subject. These are—

FIRST. GRAUWACKE, which consist of fragments of granite, or chlorite schiste, embedded in a cement principally composed of felspar.

SECOND. SILICEOUS SANDSTONE, formed of fine quartz or sand, united by a sileceous cement.

THIRD. ALUMINOUS SCHISTE, OR SHALE, consisting of the decomposed materials of different rocks, cemented by a small quantity of ferruginous or siliceous matter, and often containing the impression of crystals.

FOURTH. IRONSTONE, formed of nearly the same material as the foregoing, but containing a much larger quantity of oxide of iron.*

By which it appears that the component minerals of those four groups of strata, from the non-fossiliferous series up to the shale and old red sandstone of the coal measures, (exclusive of calcareous matter), are 1. Quartz; 2. Felspar; 3. Mica; 4. Hornblende; 5. Clay Slate; 6. Chlorite; and 7. Talk—the two last only occasionally. When these are analysed into their component elements, they are respectively found to consist as follow:—

1. QUARTZ—Almost entirely of silica, a little alumina, or oxide of iron, and combined with water.
2. FELSPAR.—63 parts silica, 17 alumina, 13 potash, 3 lime, and 1 oxide of iron.‡
3. MICA—Which consists of 46 parts silica, 10 alumina, 50 potash, 14 oxide of iron, and 1.50 oxide of manganese.‡
4. HORNBLENDE—Silica 42 parts, alumina 12 parts, 30 oxide of iron, 11 of lime, magnesia 2.25, 1 feruginous manganese, and water.‡
5. CLAY SLATE—Affords by analysis 49 parts silica, 23 alumina, 11 oxide of iron, and 5 potash.
6. EARTHY CHLORITE—Consists of 43 parts oxide of iron, 26 silica, 18 alumina, 8 magnesia, and 2 muriate of soda.‡
7. TALK—Has 62-100ths silica, 27-100ths magnesia, alumina, 1.50, oxide of iron 3.50, and water 6.‡ †

Thus, by continuing our researches, we have reached a point from whence it can be clearly discerned, that the whole of those vast rocky formations which contribute so essentially to form the surface of the Earth, when traced to their ultimate constituent principles, are found to be composed of a few simple elements, scarcely exceeding twelve in number; and that they might, perhaps, be found to owe their origin to a still smaller number of undecomposable substances, had we the power, or had chemistry the skill, to analyse still more minutely the objects of its own discovery.

* Chemistry, by Hugo Reid, p. 154, deduced from Sir Humphrey Davy's Agricultural Chemistry.

† Theorem, 103. Chemistry, by Hugo Reid. And Chemical Dictionary, by Dr. Ure.

Those thus distinguished (‡) are confirmed, or nearly so, by Mr. Lyell's Tables.

This point, then, under present circumstances, may be considered for all practical purposes, an ultimate one. And I shall next endeavour to convey some conception—imperfect I fear it will be—of the means whereby those elements were separated from the primeval ocean, which held them in suspension and combination, and became transformed into those successive layers or strata, which, when the continents arose from their recumbent position by centrifugal impetus, assumed their destined places as the chief supporters of the primary nucleii of the mountain masses.

It must not, however, be attempted to be concealed, that we have reached an extremely difficult part of our labours; the more so as it is quite impossible to attempt anything like a detailed exposition of the manner in which those stupendous works were conducted in the great laboratory of nature.

And, therefore, without wasting time and attention in the unsatisfying and fruitless attempt to penetrate into periods too remote in the history of the world's creation, or endeavouring to conceive its rudimentary elements, before they were in that condition in which it has pleased the Creator to introduce them to our knowledge in the sublime and comprehensive announcements of Genesis, or attempting to trench on those hidden grounds which are beyond the limits of human comprehension, but submissively making an unbiassed use of whatever faculties of investigation it has pleased Providence to endow us with, let the attention be directed to enquire into these works, which, even in His estimation, appeared "very good," and are spread out as a field on which to exercise the powers of mind conferred upon us, and whose contemplation, we trust, will occasion sentiments of delight and adoration, when the understanding shall have become convinced, and we are enabled to behold them in the clear light of heaven!

It is by such considerations as these, that the mind—debarred from wasting its powers in endeavouring to comprehend incomprehensible things—can best apply its unimpaired energies to the work which lies before it. I therefore trust that in this frame of spirit, we may be enabled to imagine a shoreless mass of dark tremulous water [whose purified remains are the seas of the present day], flowing in a slow, secular, unvarying, and uninterrupted course round a non-rotating sphere, and charged with the elements of countless stratified rocks, while it also held the gaseous constituents of the present outstretched firmament in combination with the mineral ingredients; and doing so, let us endeavour to determine the probable consequences. And, first of all, let it be shown how this secular flow of the primitive water round the circumbounded sphere, ere it had rotatory motion, could then have existed; happily, the amiable writer on the *Connexion of the Sciences*, has provided an illustration of the present tides, which by analogy will render this quite evident.

"It is proved," says that accomplished writer, "by daily experience, as well as by strict mathematical reasoning, that if a number of waves or oscillations be excited in a fluid by different forces, each pursues its course, and has its effect independently of the rest. Now, in the tides there are three kinds of oscillations, depending on different causes, and producing their effects independently of each other, which may therefore be estimated separately.

"The oscillations of the first kind, which are very small, are independent of the rotation of the earth; and as they depend upon the motion of the disturbing body in its orbit, they are of long periods. The second kind of oscillations depends upon the rotation of the earth, therefore their period is nearly a day. The oscillations of the third kind vary with an angle equal to twice the angular rotation of the earth, and consequently happen twice in twenty-four hours. These are the semi-diurnal tides so remarkable on our coasts. They are occasioned by the combined action of the sun and moon; but as the effect of each is independent of each other, they may be considered separately."

As the first only of these bears upon the present subject, I shall enter more particularly into it.

"The particles of water," says the same writer, "under the moon are more attracted than the centre of gravity of the earth, in the inverse ratio of the square of the distances.* Hence they have a tendency to leave the earth, but are retained by their gravitation, which is diminished by this tendency. On the contrary, the moon attracts the centre of the earth more powerfully than she attracts the particles of water in the hemisphere opposite to her; so that the earth has a tendency to leave the waters, but is retained by gravitation, which is again diminished by this tendency. Thus the waters immediately under the moon are drawn from the earth at the same time that the earth is drawn from those which are diametrically opposite to her; in both instances producing an elevation of the ocean of nearly the same height above the surface of equilibrium; for the diminution of the gravitation of the particles in each position is much the same, on account of the distance of the moon being great in comparison of the radius of the earth. Were the earth entirely covered by the sea, the water thus attracted by the moon would assume the form of an oblong spheroid, whose greater axis would point towards the moon, since the columns of water under the moon and in the direction immediately opposite to her, are rendered lighter in consequence of the diminution of their gravitation; and in order to preserve the equilibrium, the axis 90° distant would be shortened. The elevation, on account of the smaller space in which it is confined, is twice as great as the depression, because the contents of the spheroid always remain the same.

"If the waters were capable of assuming the form of equilibrium instantaneously, the form of the spheroid, its summit, would always point to the moon, notwithstanding the earth's rotation. But, on account of their resistance, the rapid motion produced in them by rotation, prevents them from assuming, at every instant, the form which the equilibrium of the

* It will of course be understood, that although the sun and moon were not illumined at the period we treat of, yet the consequences resulting from the gravity of the unillumined bodies were the same as at present.—Author.

forces acting upon them requires. Hence, on account of the inertia of the waters, if the tides be considered relatively to the whole earth and open sea, there is a meridian about 30° eastward of the moon where it is always high water both in the hemisphere where the moon is, and that which is opposite. On the west side of this circle the tide is flowing, on the east it is ebbing, and on every part of the meridian at 90° distant it is low water. This great wave, which follows all the motions of the moon as far as the rotation of the earth will permit, is modified by the action of the sun, the effects of whose attraction are in every respect like those produced by the moon, though greatly less in degree; consequently a similar wave, but much smaller, raised by the sun, tends to follow his motions, which at times combines with the lunar wave, and at others opposes it, according to the relative positions of the two luminaries; but as the lunar wave is only modified a little by the solar, the tides must necessarily happen twice a day, since the rotation of the earth brings the same point twice under the meridian of the moon in that time, once under the superior, and once under the inferior meridian. . . . . . .

"Besides these remarkable variations, there are others arising from the declination or angular distance of the sun and moon from the plane of the equator, which have great influence on the ebb and flow of the waters. The sun and moon are continually making the circuit of the heavens at different distances from the plane of the equator, on account of the obliquity of the ecliptic, and the inclination of the lunar orbit. The moon takes about twenty-nine days and a half to vary through all her declinations, which sometimes extend $28\frac{3}{4}$ degrees on each side of the equator, while the sun requires nearly three hundred and sixty-five days and a quarter to accomplish his motion from tropic to tropic through about $23\frac{1}{2}$ degrees; so that their combined motion causes great irregularities, and, at times, their attractive forces counteract each other's effects to a certain extent; but, on an average, the mean monthly range of the moon's declination is nearly the same as the annual range of the declination of the sun; consequently, the highest tides take place within the tropics, and the lowest towards the poles."*

To comprehend thoroughly the nature of the luni-solar current which must have periodically traversed the whole extent of the primitive ocean, there requires only to be added to this beautiful and perspicuous illustration of the theory of the present tides, the conditions peculiar to our planet previously to the formation of the light, namely, its non-diurnal rotation round its axis; the universality of the ocean; and the circulation of our planet in space round the unillumined sun, accompanied by its opaque satellite, the moon; in which state, the force and effects of gravity being the same then as now, it is evident that a current flowing from east to west would be constantly circulating round the globe, whose oscillations would vary in degree, and keep pace with the circulation of the moon in its orbit, and, consequently, would take place twice within the lunar month, and produce the greatest disturbance of the aqueous balance,

* On the connection of the Sciences, pp. 105—110. If more information be required on this point, please refer to Herschel's Astronomy, chap. xi.

and its velocity upon those parts, now the equator, where it had to perform the greatest circuit, while it diminished to nothing where the poles of revolution now are.

The only other peculiarity is, that the non-rotating earth presented the same side towards the sun as it revolved in annual circle round its unillumined centre, and, as a consequence thereof, according to the foregoing theory of the tides, there would be two points on the earth's surface having luni-solar tidal ridges; the one immediately under the sun, the other 180° from it, or diametrically opposite; while it must not be lost sight of, that in consequence of there being no rotation of the earth, the attractive influence of the moon and sun would exercise full power, unrestricted by the counteraction of rotation in the water, as shown that it does at present by the extracts just given; and, consequently, the primeval water being capable of assuming the form of equilibrium, would spontaneously occasion all the results flowing therefrom.

In confirmation of the general argument, I take occasion to observe, that there seems to be no doubt of the fact, *that the primitive circumfluent water was* CHEMICALLY *saturated with mineral elements, which in succession were abstracted from them by deposition, through the agency of commensurate means*, to which frequent and particular allusion will shortly have to be made. This truth seems to be admitted by all who have paid any attention to the subject, and, therefore, I shall only insist on the fact itself of the *chemical saturation of the original ocean.*

To saturate any mass of water with ingredients soluble in it, the most effectual means which can be adopted is to charge the menstruum throughout with finely comminuted material, in order that the powers of absorption and chemical affinity inherent in the fluid may be equally, generally, and effectually brought into exercise; while those powers are considerably augmented by the simultaneous presence of certain gasses, especially oxygen, which it is known everywhere abounded in the primitive water.

Without presuming determinately to assert that such did occur during the development of the great plan of creation at a period so remote, and while the stony concretions of the earth's surface were so devoid of denotation by organic remains, yet we seem warranted, from a combination of the known effects of the general laws which then prevailed, together with the actual findings of geologists, to suppose, that there might have been a stage in the earth's geological history, when the means employed to form concentric layers of rock may have been so simple as to be little less rudimentary than the method alluded to; and that the circumfluent water, in order that it might become thoroughly and generally saturated, *chemically*, with the elements afterwards deposited in a crystaline arrangement of structure, was *mechanically* surcharged with finely comminuted mineral material.

When we contemplate the peculiar circumstances of the earth at the period during which those deposits are considered to have been made—unknown to rotatory motion, unaffected by external light, and surrounded everywhere by the primeval ocean, "the earth without form and void, darkness on the face of the deep,"—there is no difficulty in perceiving, that the law of *attraction* acting on those particles of inert matter, free to percolate through water, would be wholly unabated by any of those counteracting causes which, under a different condition of the earth, might have impeded their progress to the bottom of the ocean. The several descriptions of mineral matter, besides, which constitute the inferior stratified or non-fossiliferous rocks, are represented by numbers so comparatively high in the scale of specific gravities—for instance, fibrous quartz 3.25, felspar 2.57, hornblende 3.25, mica 2.65, clay slate 2.65, oxide of iron 3.45, chlorite 2.60, and talk 2.77, that it must be confessed they would be specially amenable to the influence of the force in question, and be more readily precipitated from a fluid holding their surplus quantity in mechanical suspension; while we have only to imagine, what cannot very well be doubted, that aqueous crystalization, for which all the attendant circumstances were admirably adapted, was in full operation at the same time, to be able readily to recognize how, between these two causes, the precipitated rocks of that period would assume "a confusedly crystaline" structure, and be composed of the comparatively ponderous materials to which allusion has just been made.

The result of those combined operations on the general plan, besides so far purifying the water, would be to lay a solid base, on which fixed animals and other apulmonic ones of restricted motion were to dwell, and acotyledonous plants were afterwards to grow, both contributing to the perfection of the rocky zone which, for the very purpose, they were made to tenant; while the pre-deposition of so much mineral matter, by means next to mechanical, would save those organized beings—incapable by their conformation of evading it—from being suddenly entombed in a descending mass of earthy matter.

I find a confirmation, to a certain extent, of this opinion, in the idea which Mr. Whitehurst formed, as early as 1786, when "the enquiry" which he was then instituting into the "formation of the Earth," required that he should direct his attention to this incipient part of its history. While, after what has been written, it need hardly be pointed out how widely I dissent from the concluding words of the extract, or from any other which would occasion the erroneous conception that there ever was a stage of the creation when that which existed was less under regulation, although it may be during one which we are pleased to consider primeval and obscure. The elements, then, no doubt were incipient, but they were being created in perfect order, and according to a plan which was

devised from all eternity, and executed with unerring wisdom. The following are Mr. Whitehurst's conclusions on the subject in question :—

"It will be readily granted, that if the earth was created, it must have been brought into existence either in a solid, or in a fluid state : if we suppose the former, it must have been dissolved, and this by an universal dissolvent principle : therefore, since no such principle is yet known to exist in nature, it seems much more reasonable to conclude, that the fluidity of the earth was owing to the first assemblage of its component parts, than to any subsequent solution. . . . . . .

"The fluidity of the earth manifestly implies that the particles of matter which now compose the strata and all other solid bodies, were not originally united, combined, or fixed by cohesion, but were actually in a state of separation, as particles of sugar or salt dissolved and suspended in water.

"It is a truth universally known, that the component parts of the most dense bodies become suspended in whatever menstrua they are dissolved; as for instance, the particles of gold in *aqua regia*, silver in *aqua fortis*, salts in water, and water in air Nay, we may likewise add, that the component parts of mercury, in the act of distillation, become suspended in air, notwithstanding the specific gravity of the former is to that of the latter, as 11,000 to 1, nearly. Such, therefore, are the consequences necessarily arising from the infinite divisibility of matter, none being heavier or lighter than another, when thus reduced to their original elementary principles.

"Whence it appears, that when the component parts of the earth were first assembled together, they were in a state of uniform suspension, and seem to have composed one general undivided mass or pulp, of equal consistence and sameness in every part, from its surface to its centre; and, therefore, constituted that particular state and condition of the earth which the ancients have named *chaos*, and have described as a confused mass or pulp, composed of all the various elementary principles blended together, and *without form and void*. That is to say, the chaos had not yet acquired an oblate spheroidical form, and the component parts thereof were void of that arrangement which constitutes bodies of different denominations, as *air*, *water*, *stone*, *minerals*, &c.; but the whole mass composed of the various elementary principles blended together in one confused heap."*

As already observed, sedimentary accumulation seems to have been only one of the means employed, at that early stage of the Creation, to form the bases of the stratified rocks; their mineralogical character clearly indicating that almost from the beginning, at least as far back as geologists have yet penetrated, aqueous crystalization was an influential and a general agent in the hands of the Omnipotent to produce, in perfect order, the framework of those rocky layers, those confusedly crystaline masses described by M. de la Beche and the other geologists whose works have been quoted.

When we look upon crystalization from aqueous elements, which it seems to have pleased the Creator to have employed ere there was a dawn, even, of animal or vegetable existence; and when

* Enquiry into the Formation of the Earth, by John Whitehurst, F.R.S. London, 1786.

the beautiful and symmetrical arrangement of the particles, in the many-formed mineral crystals, is contrasted with the simple juxtaposition of particles in the structure of other inert masses, we cannot avoid being impressed with the belief that *crystalization* fills up a gap, or forms an intermediate link, as it were, in the agency of creation, between mere inert matter, and the organic forms which denote animal and vegetable life. Although neither the reproducing creature nor the propagating plant be there, yet *polarization* is so far endued with those energies of perpetuation, that when the same material elements are placed within its reach and under its control, the same forms and similar symmetrical arrangements of particles invariably follow, so that cube succeeds cube, and rhomboid succeeds rhomboid, as certainly and as persistently as patella does patella, or equisetum equisetum. It is true they are not reproduced, the one by the other; nevertheless, from causes much more applicable to the then condition of our planet, owing to its universality, and possibility of being employed, simultaneously, at almost every pin's point throughout the whole extent of the earth's surface, and at the bottom of its dark and circumfluent ocean, equivalent effects were produced, and the design of the Creator accomplished.

This interesting but comparatively modern branch of science has been made the theme of so many works of late, and been so much brought before the learned, that scarcely anything beyond allusion requires to be made to the Theorems which have been embodied here. They are numbered *one hundred and eleven*, and *one hundred and twelve*. Neither need protracted evidence be adduced to establish their contents; yet the following brief notices may prepare the mind for the application which is intended to be made of them hereafter:—

"It remains," says Mr. Donovan, "to consider the restoration of cohesion to bodies in which that force has been suspended. . . . . . This may have been effected through the intervention of a liquid. If a large quantity of sugar be dissolved in a small quantity of boiling water, and the syrup allowed to grow cold, the attraction of cohesion will begin to take effect between its particles, and, at length, the sugar will once more become a solid.

"But in this case, as in many others, whatever may have been the original state of the sugar, it always, in resuming its solidity, assumes a particular one of great regularity and beauty.

"It was originally opaque; it is now transparent. It was originally a shapeless mass; it is now a prism of six sides, in regularity and lustre scarcely to be surpassed by the products of the lapidary's wheel. A solid of this symmetrical form, and of spontaneous production, is called a *crystal*, and the process by which it is produced is called *crystalization*. . . . . Many bodies are found naturally in the crystaline state, as various precious stones and minerals."*

"Crystalization is an effect," says Mrs. Somerville, "of molecular at-

* Chemistry, in Cab. Cyc. pp. 17, 18.

traction, regulated by certain laws, according to which atoms of the same kind of matter unite in regular forms—a fact easily proved by dissolving a piece of alum in pure water.

"The mutual attraction of the particles is destroyed by the water, but, if it be evaporated, they unite, and form, in uniting, eight-sided figures, called octahedrons. . . . . . It is quite clear that the same circumstances which caused the aggregation of a few particles would, if continued, cause the addition of more; and the process would go on so long as any particles remain free round the primitive nucleus, which would increase in size, but would remain unchanged in form, the figure of the particles being such as to maintain the regularity and smoothness of the surfaces of the solid, and their mutual inclinations. . . . . .

"A variety of substances in crystalizing combine chemically with a certain portion of water, which, in a dry state, form an essential part of their crystals; and, according to the experiments of MM. Haidinger and Mitscherlich, seem in some cases to give the peculiar determination to their constituent molecules.

"These gentlemen have observed that the same substance, crystalizing at different temperatures, unites with different quantities of water, and assumes a corresponding variety of forms. . . . . .

"It must be observed that these experiments give entirely new views with regard to the constitution of solid bodies. We are led from the mobility of fluids to expect great changes in the relative positions of their molecules which must be in perpetual motion, but we were not prepared to find motion to such an extent in the interior of solids. . . . . .

"All these circumstances tend to prove that substances having the same crystaline form must consist of ultimate atoms having the same figure and arranged in the very same order; so that the form of crystals is dependent on their atomic constitution."*

It fortunately happens that those views have been fully corroborated by the discoveries of others, who have closely applied themselves to the experimental part of this branch of science; and not resting satisfied by merely propounding the *rationale* of a crystal's formation, have set about, and actually produced them from the ingredients of which they were known to be composed. Allusion in this is made more especially to Mr. Cross, M. Bequerel, and Dr. Farraday. The first, having made electrical phenomena his study for many years, states the circumstance of a voltaic apparatus remaining in constant action for twelve months, and from the influence of this continued electric action, he had produced, not only crystals of lime, but he had likewise submitted powdered flint to its influences, and found that around the positive pole, crystals of quartz were formed, but not touching the wire. He subsequently produced crystals of iron pyrites at the negative pole from elements of these crystals; and has now various crystals of copper, tin, silica, and lime, in daily formation. The crystals of aragonite were formed from the water of a cave in Somersetshire, highly charged with the carbonate and sulphate of lime, by sub-

* Connexion of the Sciences, pp. 124, 127.

mitting this water to the action of a common water-battery (for he used no acid), in nine days' time. He also mentions a very material and curious fact, *that light is detrimental to the progress of crystalization*, and that the action of the battery was greater between the hours of seven and ten in the morning, being at that period, from repeated observations, at its maximum; and at the same hour in the evening, at its minimum. Barometrical, thermometrical, and other assumed causes he found to have no effect on this latter circumstance.*

It will be seen by the following extract from Professor Buckland's late work, that he adopts views somewhat similar to those brought to light by Mr. Cross's experiments:—

"The experiments of M. Bequerel," he observes, "on the artificial production of crystalized insoluble compounds of copper, lead, lime, &c., by the slow and long-continued reaction and transportation of the elements of soluble compounds, appear to explain many chemical changes that may have taken place under the influence of feeble electrical currents in the interior of the earth, and more especially in veins. I have been favoured by Professor Wheatstone with the following brief explanation of the experiments here quoted:—

"When two bodies, one of which is liquid, react very feebly on each other, the presence of a third body, which is either a conductor of electricity, or in which capillary action supplies the place of conductibility, opens a path to the electricity resulting from the chemical action, and a voltaic current is formed which serves to augment the energy of the chemical action of the two bodies. In ordinary chemical actions, combinations are effected by the direct reaction of bodies on each other, by which all their constituents simultaneously concur to the general effect; but in the mode considered by Bequerel, the bodies in the nascent state, excessively feeble forces are employed, by which the molecules are produced, as it were, one by one, and are disposed to assume regular forms, even when they are insoluble, because the character of the molecules cannot occasion any disturbance in their arrangement. By the application of these principles, that is, by the long-continued action of very feeble electrical currents, this author has shown that many crystalized bodies, hitherto found only in nature, may be artificially obtained."†

What has now been gone through will, it is hoped, have sufficiently prepared the mind for reasoning with those truths which have been brought out. To do this effectually, however, the attention will have to be carried back to a period somewhat earlier in the earth's formation. We must endeavour to realize a time when the water was charged with mineral matter in *mere mechanical suspension.*

In attempting to do this, there is particular need of the caution with which we set out, namely, to avoid trenching, in the slightest manner, on the boundary line which prohibits enquiry, and be con-

* Literary Gazette, 27th August, 1836. Further information will likewise be found in Gazette of 15th October, 1836, pp. 667, 668.

† Bridgewater Treatise, vol. i. pp. 552, 553.

tent with coming to conclusions on matters within the grasp of the comprehension; in short, to avoid the quagmires of geology, and adhere as closely as possible to its firm ground, although it may have been little trodden, and may pertain more to clear deductions than to actual research.

The way I feel inclined to look upon this part of the subject, and the view, perhaps, which is the least exposed to error, is this: We find, at the present moment, an immense mass of water contained within, and resting upon, a framework of solid rocks. When those rocks are examined into, they reveal to us, as well by their mineralogical as their geological structure, that they have been very differently formed. Those which are nearest to us, or the more recent, bear evident marks of having been carried about by water, and having been, as it were, thrown down suddenly and violently from it; like sedimentary deposits from water in agitation and motion.* Below these, again, are more extended formations exhibiting as undeniable symptoms of having been deposited slowly, tranquilly, and persistently, from water holding their ingredients so firmly in suspension as to part with them particle by particle, deliberately, and, as it were, compulsorily, by means of its animal and vegetable inhabitants.† Going downward still, there are found more compact rocks, whose stratified texture shows that they also have been the product of water, but water acted upon and seemingly drained of its material by one universal agent, which, by the infinitude of sparkling, symmetrical crystals which it has formed, evinces how general has been its operations, and how effectual its work.‡

All these have evidently been held in suspension by water; but held in such a manner, that had it not been for those successive agencies which were employed to disturb its chemical equilibrium, for wise and beneficent purposes, it might have continued holding them until now in suspension, or as long as it pleased the Creator. When we penetrate still lower, we encounter rocks whose structure is heterogeneous and confused, manifesting both the influence of crystalization, and simple aggregation of particles, apparently by mere juxta-position; and last of all we come to a species of rock, or rather a diversified series of rocks, of vast and general extent, in which all traces of deposition from water are wholly lost. They are clearly unstratified, or without symptoms of having been formed in layers or beds; while the crystalization they exhibit seems to have owed its origin more to heat than to the slow molecular aggregation of aqueous origin.§

When by an effort we take all these great and successive formations of mineral matter into our mind at once, and estimate them

* Theorem 32nd, and its proofs. † 14th Theorem, and proofs.
‡ 23rd and 18th Theorems, and evidences.
§ 23rd, 24th, and 25th Theorems and proofs; likewise table at page 128.

with relation to the quantity of water in our present seas, whose average depth is considered to be only two or three miles, the inference must of necessity be drawn, that while the water positively did contain a great part of these rocks, it could *not* contain the whole of them. It is physically impossible. There is not capacity in the ocean to have contained all the rocks of the world. Therefore, when all this is reflected on, we must come to the conclusion *that there was an epoch in the geological history of the world, when, in obedience to the laws impressed upon them, some parts of its earthy crust were condensed into a solid form, and left the turbid aqueous portion, charged with similar material, resting on the base thus formed beneath it.*

Supposing such to have been the case, and, indeed, all the facts connected with this period seem to imply that it was so, the water which, by its lighter specific gravity, assumed the exterior position would become charged with mineral ingredients *beyond what it could keep in suspension;* what it has parted with confirms this conclusion. And we have only to infer that, conformably to the laws which govern matter, it would first part with its surplus, according to the specific gravity of the ingredients, which, likewise, seems to have been the case, as shown, when the mineralogical structure of the lower rocks was explained. What is chiefly required, at present, is to direct the attention to the undeniable fact, fully evidenced by the discoveries of geologists, that the primeval water was at one period actually charged abundantly with mineral ingredients; that *from it has been deposited, at some time or other, and during the succession of ages, the greater part of what are termed the stratified rocks.* I am not solicitous about determining the precise period *when* those deposits took place, nor, at present, *how* they took place, but merely to be allowed the admission which, I apprehend, cannot consistently be withheld, that such actually did take place.

Supposing, therefore, such to have been the case, and presuming that water then possessed the same absorbing powers which it does now, and from having been surcharged with gaseous elements, that its powers of absorption would even be much greater; it follows, obviously, that the primitive water must have become *chemically* saturated with the mineral ingredients which were thus percolating through it. It is not to be expected that evidence as undeniable as that which is afforded by analysis, or by examination, can be adduced, to prove that the original ocean *was so impregnated,* but I can offer facts, that layer after layer, thin scaly sheets of stone have been deposited from it; and, in addition, the corroborative analogical evidence that water *now,* even when exposed to the evaporating influences of the atmosphere and of sunlight, is occasionally met with which holds in chemical combination ingredients almost similar to those which it is supposed the dark and atmosphereless primitive ocean contained. Without fatiguing the reader with

diversified analyses, I shall, on account of their being so well known, give that of the water of Carlsbad, in Bohemia.

According to the analysis made by M. Berzellius, and referred to by Dr. Ure, the mineral matter found in these springs consists of

Sulphate of soda	2.58714.
Carbonate of soda	1.25200.
Muriate of soda	1.04895.
Carbonate of lime	0.31219.
Fluate of lime	0.00331.
Phosphate of lime	0.00019.
Carbonate of strontia	0.00097.
Carbonate of magnesia	0.18221.
Phosphate of alumina	0.00034.
Carbonate of iron	0.00422.
Carbonate of manganese	a trace.
Silica	0.07504.
	5.46656."*

A confirmation, to a certain extent, of this last evidence, is found in a note by M. de la Beche, when treating of the "variations in the mineralogical character of the cretaceous group." The passage and note run thus:

"When we turn to the higher part of the group, into which the lower portion graduates, the theory of mere transport appears opposed to the phenomena observed, which seem rather to have been produced by deposition from a chemical solution of carbonate of lime and silex, covering a considerable area."

Then follows the note:

"If we regard present appearances, we find that silex is held in solution by thermal waters, which also, as in the case of those of St. Michael in the Azores, may contain carbonate of lime. No springs or set of springs that we can imagine, are likely to have produced this great deposit of chalk so uniform over a large surface. But although springs, in our acceptation of the term, could scarcely have caused the effects required, we may, perhaps, look to a greater exertion of the power which now produces thermal water for a possible explanation of the observed phenomena."†

This quotation and the foregoing analysis (besides many similar ones which may be seen by referring to the synoptical table of mineral waters in the same work), will sufficiently show *what diversified ingredients water can, at the same time, hold in chemical combination.*

When it is considered that the condition of the primitive ocean, charged with gaseous elements, without an atmosphere to act as an absorbent, and without the influence of the sun's rays to aid in with-

* Ann. de Chim. et de Phys. XXI. p. 248. See also Tables in Murray's Chemistry, vol. ii. pp. 741—743.

† Manual of Geology, 2nd edition, pp. 264, 265.

drawing or in volatilizing those aeriform elements, was much better adapted for holding extraneous earthy matter in solution, we shall not be surprised to find, by inference drawn from the nature of the deposits, that the following ingredients were, at the same time, suspended in the primitive ocean, viz.: silica, alumina, lime, magnesia, baryte, strontia, glucina, zirconia, potash, soda, ammonia, oxides of iron, manganese, tin, copper, and other metals, iodine, carbonic, fluoric, sulphuric, and nitric acid, with free oxygen, and other gaseous elements, which will be enumerated in the sequel.*

In continuation, I shall demonstrate the chemical laws which, under the appellation of general affinities, influence their procedure, when brought into contact by a solvent or carrier, such as the water of the circumfluent primitive ocean.

"There must be some power or influence," states Mr. Hugo Reid, "operating to draw bodies into such intimate union with each other, and to express their power, we use the term *chemical* attraction. We know not how this power operates, and know not its nature; we can only judge of it from its effects, and we see that it is the nature of these substances to be united in this way when they are brought together; also we see that a great number of other substances have a disposition to unite in a similar manner; hence we infer that there is some peculiar influence acting between substances which disposes them to unite with each other, and as they appear to be attracted or drawn towards each other, it is called *attraction*, and receives the epithet '*chemical*' to distinguish it from other kinds of attraction.

"By combination (chemical union), two different bodies unite and form a third, differing very much from either. It is chemical attraction which causes them to combine when brought together, and thus this agent is the cause of the differences which we find in bodies. Were there no such agent as chemical attraction, there would be only about 54 different kinds of substances: the simple bodies, and of these several are very rare; but chemical attraction makes these unite with each other, and these compounds unite with the simple substances, and with each other, so that we may say there is almost no end to the number of different bodies brought into existence. It draws towards each other the particles of *different* kinds of matter and binds them together, causes them when they are brought into contact to enter into new arrangements and combinations, and thus gives rise to the variety in the objects around us, and to the varied phenomena of chemistry."†

Mr. Donovan, writing on the subject of chemical affinity, thus expresses himself—

"The natural forces, gravitation and cohesion, belong, in their full development, more to mechanics than to chemistry. . . . . But there are other forces in nature to be considered which fall more exclusively within our province; and which, so far as this planet is concerned, act a part equal in importance and interest to any other."

After exemplifying the different effects which result from the immersion, in mercury, of a rod of iron, and of a rod of gold, and

* Theorems 96, 97, 99, and 100.

† Chemistry, by Hugo Reid, p. 8.

showing that part of the mercury has become intimately combined with the gold on the surface of the latter, he proceeds to say—

"This, then, is to be acknowledged as a different exhibition of the attractive force that pervades all matter; it is distinguished by the name of *chemical attraction*, or simply by the term *affinity*—a more convenient but less expressive term; and it differs from all known forces in its agency. . .

"This kind of attraction acts upon matter in all states, whether solid, liquid, or gaseous.

"When a piece of sugar is thrown into water, it sinks to the bottom; yet, after a time, by the taste of the water it will be proved, contrarily to the laws of gravity, to have ascended towards the top and spread to all other parts; it must, therefore, have been gradually attracted. The same would happen with salt, alum, and various other articles, between which and the water affinity is known to exist. . . . . . And so, likewise, with two fluids, between which affinity subsists. Thus: spirit of wine is lighter than water, and if poured cautiously over water, it will float; but, after a length of time, it will be found to have descended to the bottom, and to be equally diffused through all parts, in consequence of affinity. But if oil be poured on water, it will remain there during any period, for it is lighter than water, and is not attracted by any strong affinity to that liquid. . . .

"This attraction does not act at any distance which can be perceived; its existence is only discoverable by its effects, but its consequences are very striking, and the changes it produces are of such a nature as cannot be overlooked. . . . . . . By melting two metals into *combination* extraordinary changes are produced. . . . . . What the nature of the change may be that is thus produced on the two metals cannot be explained, but it is certain that, in the mixed mass, the contiguity of a particle of one kind of metal produces a very decided change on the properties of the adjoining particle of the other, and a property is produced by their union which neither particle apparently possesses. . . . . .

"The change of properties which takes place when chemical attraction acts is not confined to metals, but is a general result in every case where different bodies are brought into this state of combination, or chemical union.

"Frequently we find that the properties of each body are totally changed; and that substances, from being energetic and violent in their nature, become inert and harmless, and *vice versa*. . . . . . One of the chief differences," he goes on to say, "between *chemical* and *cohesive* attraction is, that the former takes place only between the particles of different kinds of matter, whereas the latter occurs between the particles of the same kind. . . . .

"We have now to enquire," says he, "whether or not affinity is a force of very extensive operation in nature; whether it acts in the case of certain kinds of bodies only, or is a general property of matter. The facts known seem to warrant the inference that there are no two bodies between which an affinity does not subsist, ... although there may be antagonistic forces which prevent their combination. . . . . .

"Most of the great changes which are constantly taking place in nature, are instances of decomposition and chemical affinity. It is by decomposition that the solid rock becomes covered with a fertile soil; it is by the same agencies that the soil throws up its verdant clothing; that growing plants

are converted into animals by assimilation; that animals at length fall into decay, and return into their original state. In fine, it is by decomposition that the great natural processes of renovation and decay are kept in a state of perpetual circulation."*

These data comprehend all that is required to enable us to enter into the investigation of the proceedings of nature in the formation of rocky masses, by the united agency of simple deposition, of crystalization, of animal and vegetable secretion, and of chemical combination; for we have a universal solvent, holding an almost indefinite quantity of the various elementary materials in solution, and itself constituting a carrier to assist in their union; we have the radical principles of electrical phenomena; we know the names and natures of most of the ingredients employed; we are aware there was a constant current in the primeval water flowing round the globe from luni-solar influences; and that there were other currents within the water itself, caused by the unequal degrees of gravity of the aqueous strata; and being in possession of all these particulars, together with the knowledge just acquired of the nature of chemical influence and attraction over the elements of matter held in suspension, which cause them to unite together and form an almost endless variety of other substances, we may be considered fully prepared to enter on the investigation of what took place during the formation of those stratified masses *whose constitution appears evidently to have been the chief end of the co-existence and operation of all those means, and to have been wrought out during a protracted but indefinite period of non-rotation,* when all the concomitant circumstances were peculiarly favourable for the accomplishment of what was then designed.

* Chemistry in Cab. Cyc. pp. 20—25.

SECTION III.

DEPOSITION OF THE STRATA DURING THE NON-ROTATORY PERIOD.

CHAPTER X.

Position assumed, that the primeval water was chemically saturated with the mineral elements of the strata; and could, therefore, according to the laws of affinity, arrive at a static condition of chemical equilibrium. To produce any change of this state there must have been the intervention of a power beyond materialism, and the employment of an agency exempted from the law of gravitation. Aqueous crystalization apparently the first means made use of to produce that change by the Creator; evidences of this discoverable in the earlier strata. Animal and vegetable vitality next introduced to continue the same effect. Wisdom shown by the sequence of these agencies, and their influence on the progressive work of the creation. The vast extent and depth of the calcareous formations. Beneficence in the design of the relative position which these hold in the order of superposition. The mineral elements—how dissolved and held in combination by the primitive menstruum and their affinities; how they operated in causing deposition when the general equilibrium was disturbed by aqueous crystalization, and by animal and vegetable life. The wise adaptation of these constraining agencies to overcome chemical affinities, and to form substances which otherwise would have been injurious to future life. In conclusion, animal death, and the effects produced by the gaseous exhalations arising from their decomposition.

Before prosecuting our investigations more closely, by endeavouring to discover what was likely to follow from the conditions laid down in the preceding chapter, I take occasion to sum up the evidence, with the design of coming to a perfect understanding upon a point of such essential import. Having made good the position that the primeval water, which circumbounded the rocky nucleus of the earth, was, at one time, charged with mineral material, which, by some means or other, became separated from its sustaining menstruum, and was slowly and tranquilly deposited at the bottom of the ocean, it follows as a corollary, that those mineral masses were associated with that vast, shoreless, and atmosphereless body of water, *in part by chemical affinity*, and thereby held, to a certain extent, in suspension *by* it.

This must be admitted, if it even should be alleged, that a much greater proportion of the stratified rocks is the product of mechanical deposition, than what even the most liberal construction of geological research will permit; because, while the rocky elements were percolating mechanically through the water, to assume that position at the bottom which their specific gravities occasioned them to do, the ocean, for the reasons which have been assigned, must have become chemically saturated with those very percolating

ingredients, as they passed onwards and downwards. And this brings me, at last, to the point I have so long wished to reach, namely, *that the primitive oceanic water must have been, at one time, chemically charged with mineral elements.*

Now, it is a fact well known and admitted, that water—especially large masses of water—when chemically impregnated with such extraneous substances as it is capable of taking into combination in that state, continues to purge itself, as it were, of every superabundant particle of any one of these ingredients until a *static condition of perfect equilibrium is attained;* after which, if in vacuo, and *no new element be added, or none of the original ones withdrawn,* it will, for aught we know, continue to maintain the same state of chemical equilibrium *ad infinitum.** This principle is so well known and admitted, that the general argument need scarcely be retarded to bring forward evidence to prove it; although it should be borne in mind that I am treating of a period when there were neither sun-light, nor atmospheric air to operate in producing those slow but gradual changes which now, apparently almost without the interference of any agency, are certain to be the result when any solution is exposed to their influence. At the time to which I allude, neither the heating nor the chemical rays of the sun were shed upon the ocean, nor was it operated upon by the searching and all-pervading agency of the atmosphere. These were all intentionally kept back, the leading principle and main design having then been to exclude evaporation, and by all concurring means to CREATE by assimilation through SECRETION, whether we judge of this by what has been effected by the corium of a *mollusc,* by the cortical exterior of a *cryptogame,* or by the vast periphery of the Earth's mineral crust, which was thereby accumulating beneath the primeval ocean. And therefore its causes of change, whatever they were, resided entirely within its dark and atmosphereless mass, and *there,* under the directive power of the Creator, were made to produce those ends for which they were brought into being and thus peculiarly circumstanced.

I shall therefore—as the natural result of the law of equilibrium—conclude, that water, chemically charged with extraneous ingredients, would, by parting with the *surplus* atoms of any one of them, assume a static condition by the mutual arrangement of the molecules *inter se,* according to their respective affinities; and that so long as none of these ingredients were withdrawn, nor any other substance was added to them, the mass would continue in the condition of equilibrium which it had assumed.

It is stated, and with perfect truth, in the *sixty-seventh* Theorem: "*That one of the most important qualities of matter in mechanical investigation is* INERTIA, *or that property which results from its inability to produce in itself spontaneous change or action, either from a state of*

* See the 67th and 69th Theorems, and their evidences.

rest to that of motion, or vice versa, to diminish any motion which it may have received from an external cause, or to change its direction."

Now, when those two fundamental truths are brought into juxtaposition in the mind, and we take into account the condition of our planet at that period, namely, "the Earth being without form and void, and darkness upon the face of the deep;" and that it was a non-rotating sphere enveloped in a dark, atmosphereless ocean of water, reduced, by the deposition of all superabundant earthy ingredients to a state of chemical equilibrium, it must be concluded, that the *inertia* of matter would be the governing principle of the whole. As long as there was no abstraction from the mass—and nothing could, under the circumstances described, be taken from it; or no new principle impressed upon it, or addition made to its constituent particles; or no external force brought to bear upon it—a change *could not by possibility have taken place.* The primeval water, once brought to a state of chemical equilibrium—and to that condition, if left entirely to itself, it must of necessity have come—no change could, or ever would, have taken place in the mass thereafter, *unless by the interposition of something beyond and external to itself.*

This conclusion has been come to by applying the announcements of science to the condition of the earth during the early age to which I allude; while it is worthy of being remarked, that in the Scriptures alone is any adequate account to be found of those conditions which the wonderful discoveries of after-science—when carried back, and applied to the case in question—require, satisfactorily to solve the important problem of the geological phenomena. These discoveries demand that there should have been a stage in the world's geological history, when its surface should have been devoid of form; surrounded by water, and cloaked by universal darkness;—and these are declared in the simple but comprehensive language of Scripture, to have been the actual circumstances of the earth, when first introduced to our notice as "without form and void; darkness upon the face of the deep." When we take a deliberate and comprehensive review of the position now reached in this argument, it will with little hesitation be admitted, that it would be one of insurmountable difficulty were we to attempt to walk by the light of Science alone. A world without rotation—enveloped in an atmosphereless ocean—reigned over by universal darkness, and whose circumfluent water had, by the laws which regulate molecular attraction of affinity, reached a state of equilibrium; and, consequently, without some influence beyond itself incapable of alteration, are conditions which, contemporaneously operating, without the continuing influence of the Creator, would have brought the work to a conclusion in that incipient and imperfect state. For, if we turn to the astronomer, he will, after consulting his well-authenticated general laws, inform us, that consistently with those which govern

the earth's orbital motion, there could have been no addition of ponderable matter made to it after it was translated in space; neither could any abstraction have taken place without endangering the permanency of its periodical course. If, to the natural philosopher—rendered conversant, by deep and protracted study, with the laws of *inertia*—we next seek for aid, he will inform us, with that reliance which he has acquired by repeated experience, that "matter is incapable of producing in itself spontaneous change, either from a state of rest to that of motion; or of diminishing any motion which it may have acquired, or to change its direction;" that in fine, it is, as designated, wholly inert and entirely passive at the will of external causes. And, lastly, if we direct our enquiries to the chemist, in hopes that his minuter investigations into the constituent elements of material substances and their affinities may have furnished him with the knowledge necessary to relieve us from our embarrassments, we shall be met by still closer and more impassable barriers. We shall find that his laborious and instructive investigations have clearly revealed to him that the ultimate molecules of matter are governed by and obedient to the same law of inertia; their chemical affinities *being once satisfied*, they never can, of *themselves*, thereafter change; they can neither increase, diminish, nor alter their own powers spontaneously.

Hopeless of success, the enquirer—who supposes nature alone to be able to answer all the questions requisite to be put, in order to unravel the mystery—either turns aside from the arduous task, as one incapable of being satisfactorily accomplished, or rushes blindly into some wild and general speculation, wholly disregardful, not only of revelation, but of all well-investigated natural laws made known to us by modern science, in hopes that by some desperate effort he may be enabled to clear the dangerous gap which presents itself to impede his further progress. But those who are enabled to recognise the necessity of consulting the announcements of Scripture, will find, that in immediate sequence to that passage describing the static condition of the creation to which I have alluded, there is another which supplies all that is wanting; for it is written, "And the spirit of God *moved* upon the face of the waters."

It would be presumptuous to attempt to determine the period or its duration when it was essential, in the development of the plan of creation, that this immediate FIRST CAUSE should be exercised. The only key we have is what is contained in the 1st and 2nd verses of Genesis. It is, however, my belief, as it will be my care to make manifest in the sequel, that the period of non-rotation was coeval and coexistent with it, and that the other attendant circumstances of the material universe were in perfect accordance with the announcement therein made: while it must be conceded, that no being, except the Spirit of God, could have conducted a *progressive*

operation to its destined end, whose ultimate condition of perfection was known only to God.

Although it may turn out, hereafter, that more laborious geological researches may carry back the era to a remoter period than what is at present conjectured, when fossil remains may demonstrate the existence either of inferior animals or of plants, still, it is presumed, we may, with safety, for all practical purposes, adopt the impressive language of Sir R. J. Murchison, and assert,

"That the very genesis of animal life, upon the globe, has been reached by the indefatigable exertions of geologists; and that no further *vestigia retrorsum* will be found beneath the protozoic or lower silurian group, in the great inferior mass of which no vertebrated animal has yet been detected amid the countless profusion of the lower orders of the marine animals entombed in it."

And that it cannot be doubted, from the result of the rigorous examinations to which the primitive rocks have been subjected, that there are entire formations in which no traces of the remains of organized existence (animals or plants), of even the lowest or simplest grades, have ever been discovered, the mineralogical structure of the rocks revealing to us that crystalization was then the almost exclusive agent employed by the Creator to perform the work of preparation. And when it is considered with what minuteness and universality the encrusting process of crystalization would go on at the bottom of a tremulous, dark, atmosphereless ocean, of shoreless extent, charged with all the elements most conducive to its advancement, we must admire the wonderful adaptation of the means to the end: while we recognize the wisdom which devised an agency of such universal efficacy, and a promoter of such a variety of pleasing and symmetrical forms; and be grateful for the goodness which induced the employment of an intermediate instrumentality between inert matter and organized existences, that there might be abstracted from the water immense masses of mineral substances, which, had they been released from their chemical affinity with water by the instrumentality of animals and plants themselves, would inevitably have buried both beneath their vast accumulations; while at the same time, the minutest particles of matter, by being subjected to the peculiar elaboration required to polarize them and so to induce crystalization, became wrought into combinations which no other means could have effected; and, substances which otherwise would have been hurtful to after states of the creation, were thereby neutralized and locked up, in perfect innoxious security, for the future uses of the world's inhabitants.

The crystalization which is here mentioned, induced by *aqueous* solubility, although akin to that which was afterwards produced by *fusion*, from heat, arising from the friction occasioned by the movement *inter se* of the mineral masses of the earth's crust, when the sphere was first made to rotate around its axis, should be clearly

distinguished, in its objects and effects, from this latter: aqueous crystalization having affected the stratified formations more exclusively, and having evidently been brought into operation at a different stage of the creation; indeed, long before crystalization from caloric induction could have been made an agent, as it certainly was at its appropriate period, in the great work of the world's formation then going on.

Having so recently given the more particular evidences regarding aqueous crystalization, and made these general remarks, I shall not now require to do more, with respect to this very interesting and modern branch of study, than to recapitulate what is stated in the *hundred and eleventh* Theorem, viz., "*That when substances are rendered fluid with perfect mobility amongst their particles, either by igneous fusion or by solution, and are suffered to pass with adequate slowness into the solid state, the attractive forces—called homogeneous attraction—frequently re-arrange these particles into regular polyhedral figures or geometrical solids; to which the name of* CRYSTALS *has been given. That mere approximation of the particles is not, however, alone sufficient to produce crystalization, they must also change the direction of their poles from the fluid collocation to their position in the solid state, which may be effected by the following means, namely:—*1. *By vibratory motion, communicated either from the atmosphere or any other moving body.* 2. *By contact of any part of the fluid with a point of a solid of similar composition previously formed, or other substance.* 3. *By the slow and continued agency of voltaic electricity operating in water. That darkness in most instances favours crystalization. That heat, likewise, exercises considerable influence on these phenomena; and, lastly, that the same substance, in crystalizing, not unfrequently assumes a diversity of forms; though, in general, the same substance, under similar circumstances, assumes the same form.*"

The evidence afforded by this Theorem, founded upon the testimony of men who have made this branch of mineralogy their attentive study, leaves not a doubt on the mind as to the existence of a progressive power having been exercised over the particles of *mineral* matter, by which they became symmetrically arranged into crystals of adamantine hardness and brilliancy, in a manner precisely analogous to the arrangement more frequently witnessed amongst the less adherent particles of neutral salts; and that all the conditions of the earth, at the period I allude to, as supposed in this theory, were precisely those most conducive to foster and to promote the aqueous crystalization of mineral matter, on a scale commensurate to the magnitude of the design. Having arrived at this conclusion, it only now requires to be seen, *whether the mineralogical structure of the rocks, which constitute the basis of the Earth's crust, affords corresponding evidences of the silent, slow, and ubiquous work of this influential agency.*

To attain this end I shall recapitulate the words of the *hundred*

and twelfth Theorem, in which it is stated, on the authority of those writers who sustain that proposition,

"*That most of the rocks which compose the mineral crust of the earth are in a crystalized state.* GRANITE, *for example, consisting of crystals of quartz, felspar, and mica;* MARBLE, *of crystals of carbonate of lime, &c. And that the whole phenomena attendant on crystalization go to prove, that substances having the same crystaline form, must consist of ultimate atoms, having the same figure, and arranged in the same order, so that the form of crystals is dependent on their atomic constitution.*"

In support of this abstract form of stating the subject, I shall next take occasion to add a few descriptive extracts from the works of those who have favoured the world with the result of their interesting enquiries into this branch of mineralogical geology. M. de la Beche says—

"Granite is a confusedly crystaline compound of quartz, felspar, mica, and hornblende. . . . . . It is occasionally porphyritic, large crystals of felspar being disseminated through the mass, showing that, however confused the crystalization may have been, circumstances were such as to permit the production of distinct crystals of felspar. Greenstone and the other rocks usually termed *Trappean*, vary in texture from an apparently simple rock to a confusedly crystaline compound, in which crystals of felspar are disseminated. . . . . .

"Such are the rocks commonly considered unstratified. It will have been seen that they so pass into one another that distinctions are not easily established between them. Mineralogically, granite passes through various stages, and graduates into the compounds named greenstone and others of the trappean class."*

Mr. Lyell observes—

"We have now to examine those crystaline (or hypogene) strata to which the name of *metamorphic* has been assigned. The last term expresses a theoretical opinion that such strata, after having been deposited from water, acquired by the influence of heat and other causes a highly crystaline texture. . . . . . 'There are,' says Professor Sedgwick, 'three distinct forms of structure exhibited in certain rocks throughout large districts, viz., stratification, joints, and slaty cleavage, the two last having no connexion with true bedding, and having been superinduced by causes absolutely independent of gravitation.' . . . . . It has been observed by Mr. Murchison, 'that in referring both joints and slaty cleavage to crystaline action we are borne out by a well-known analogy, in which crystalization has in like manner given rise to two distinct kinds of structure in the same body.' . . . .

"Sir John Herschel, in allusion to slaty cleavage, has suggested, 'that if rocks have been so treated as to allow a commencement of crystalization, or heated to a point at which the particles can begin to move amongst themselves, some general law must determine the position in which these particles will rest on cooling; and when this is the case it must of course determine a cleavage plane; this takes place in many of our chemical manipula-

* De la Beche, pp. 486—489.

tions and in the arts, and what occurs in our experiments on a minute scale may occur in nature on a great one.'"*

"What then," asks Professor Phillips, "is the fruit of all this discussion? It is the conviction that the gneiss, mica slate, primary limestone, quartz rock, &c., are stratified rocks, ... but that the causes which tend among all rocks to complicate the stratification with new structures, have gone to the maximum in these the oldest of all; the principal of these causes being heat, either locally exhibited in the neighbourhood of igneous crystalized rocks, or generally pervading the whole mass of deposits."†

The following corroborative testimony is from Mr. Ramsay's admirable little Treatise on the Geology of Arran; an island, our readers are aware, which presents great facilities for such investigations:—

"The mass of the granite of Goatfell is the large grained variety; but there are found in it many veins of a fine, compact texture, which indeed are common throughout all the coarse grained granite of Arran. . . . . The constituent parts of the latter are felspar, quartz, and mica; and the differences in texture are owing to the variable proportions and sizes of these constituent minerals. Generally the felspar predominates, next quartz, and lastly mica, in comparative small quantities.

"There are three varieties of felspar, the first of a light brown colour, the second almost pure white, and the third, commonly called glassy felspar, exhibiting a brilliant polish when fractured. . . . . Of the quartz there are also several varieties, viz., common white quartz, pale yellow, light grey, colourless quartz, or pure rock crystal; light brown, dark brown or smoked quartz, and sometimes, though rarely, it is almost black. . . . . The transparent and dark varieties are by no means rare, and frequently attain to a considerable size. They are usually found in the form of hexagonal prisms, and occur along with crystals of felspar, in those rounded cavities which are so common in this granite. Specimens are also found, in which the transparent and light grey varieties alternate in layers, like the various colourings of an agate.

"The mica is much more sparingly diffused than the other minerals, and is usually found in small scales of a dark brown or black colour. The fine grained granite does not occur in mass in the neighbourhood of Goatfell, being only found in the form of penetrating veins. . . . . Wherever it penetrates the coarse granite in veins, there it exhibits the finest and most compact texture, and frequently the quartz and mica totally disappear, leaving the remaining constituent in the form of a compact felspar.

"The phenomenon of its superior fineness in the veins is easily accounted for, when it is considered that when the melted matter forced itself into the fissures in the coarse grained or older granite, and thus came in contact with a cooling substance (the coarse granite being previously consolidated), it would crystalize more rapidly, and consequently in smaller crystals, than if the cooling process were more gradual. In this granite mica is only to be found in very small black scales, sparingly intermingled with the quartz and felspar. The two latter constituents are sometimes mingled in nearly equal proportions, but very frequently the felspar predominates."‡

* Lyell's Elements of Geology, vol. ii. pp. 379, 400. Silurian System of Rocks, p. 246.

† Treatise on Geology, p. 75.

‡ Geology of Arran, by Andrew C. Ramsay, pp. 5, 6.

The universal and sustained agency which we have thus been made aware was going on throughout the primeval ocean, forming into solid masses many of its elements, and constituting them into the rocky barriers which afterwards were to confine the waters themselves within their destined limits—when the plan of Creation should be more fully developed—would, by disturbing the chemical equilibrium, release other earthy ingredients, by the extraction of those particles which formed the crystals; whilst the mechanical deposition of those elements, thus liberated, would confer on the conjoint formation a confusedly crystaline texture.

Were it essential, it might be easy to show that the continued action of a single agency, such as the one here alluded to—however searching and universal it may have been in its effects upon impregnated water, so well calculated to promote them—would have again brought the entire aqueous body into a static condition of equilibrium; and have occasioned the necessity of introducing some *new* power, in order to perpetuate the work of deposition, which, in that epoch, it seems to have been the design of a beneficent Creator to accomplish. Fortunately, however, I am spared the necessity of this investigation. The fossil exuviæ of inferior classes of animals and plants which are found embedded, nay, partly constituting the very rocks themselves, sufficiently attest this great truth, and show that besides crystalization—which may be looked upon as an earlier means of transforming those aqueous compounds into solid matter—there were other scarcely less ubiquous, silent, and indefatigable agents employed in this great work of solidification; and which, while they were progressively increasing, and some were encrusting themselves with shelly coverings of carbonate and phosphate of lime, and others with ligneous fibres, were all alike fulfilling the decrees of Providence, and preparing the earth and the water for their relative fitness and position when they should, by the diurnal rotation of the sphere, be finally transformed into "the habitable globe," the solid portion rising to restrain the purified aqueous part within the bounds which appear to have been from the beginning designed for it. Nor should it be overlooked that it was only from such a source as the life-giving Creator that this new principle of animal and vegetable vitality could have been derived; and that He alone could thus interpose an effectual and successive agency to interrupt the state of equilibrium which the water would otherwise have inevitably assumed.

Were it not that I have undertaken the rigid task of endeavouring to explain these wonders, and am bent on convincing the under- could cause those comparatively insignificant instruments to drain standing, not affecting merely the imagination, I should feel an irresistible desire to ponder over and admire the amazing stretch of wisdom and power, which, by means apparently so simple could effectuate ends so vast, and designs so beneficent; the primitive

ocean of elements which, in other states, would have proved injurious; and could, with the matter thus solidified, form that which in due time was to set bounds to the water, which, with shoreless expansion, had circumbounded the whole earthy nucleus!

It is so entirely in accordance with the manner of the growth of plants, and with that in which the lower apulmonic tribes of animals and zoophytes propagate, to extend themselves from centres or foci, that it need scarcely be particularly proved. Those centres would, of course, be originated where it was foreseen by the Creator to be most conducive, for the ulterior development of His plans, to place them. It would be alike superfluous and inconclusive were I to occupy time or attention surmising *when* they commenced; or whether animal life preceded vegetable existences; whether the reverse was the case, or whether they commenced simultaneously. The conflicting opinions of geologists, although deduced alike from the organic remains of the respective divisions, would seem to leave the field open to those who surmise that both may have had the dawn of their existence on our planet at the same period,* although at first, in number and variety, the objects of the animal economy—which seem to have been willed into existence together—far exceeded those of the vegetable kingdom; but, in the course of ages, those of the latter great division (the plants) gained upon the former, until at length, about the period when the light was to be formed, and the earth made to rotate around its axis, or when the great coal fields were being stored with ligneous deposits, *vegetable* greatly surpassed the proportion of *animal* life. The stereotyped remains of each of those classes of existences pertaining to the inferior branches of their respective kingdoms, enable us still to read, with almost unfaltering precision, the history of their bygone but essential labours at the bottom of a dark and boundless ocean of considerable depth, and charged throughout with the materials I have so often alluded to, held in firm chemical combination by the aid of associated gaseous elements.

It is when the subject is looked upon in this point of view, that we behold with greater vividness the combination of wisdom and benignant goodness which characterized all the proceedings of the Creator: for, while those animals, zoophytes, and plants were abstracting from the water that which was necessary to be taken from the primitive ocean, before it could be made the seas of the present day, they were drawing down the material to the bottom, and encrusting with it, through their own bodies, film after film, as it were, the vast submarine surface of the earth, and causing it gradually to expand to its destined size, preparatory to its future change of posture and form; while, during the whole process, those

* It appears to be Dr. Buckland's opinion, that the creation of marine animals and plants were contemporaneous, and that both commenced in the lowest transition stratified masses.—Bridgewater Treatise, vol. i. p. 18.

successive creations were each fulfilling to the uttermost the functions of their limited career of existence, and deriving therefrom whatever satisfaction they were capable of enjoying. Why it should have seemed good to an all-wise Creator thus gradually to have introduced the living principle into the material universe, and to have adopted this protracted method of "creating the materials of the heaven and earth at the beginning," is not for me to enquire; nor are such enquiries within the scope of this work, even were it within my power to accomplish such an undertaking. The organic remains, which everywhere exist, afford undeniable evidences that it pleased him to do so, to restrain for a time, as it were, his life-giving influences, and to lavish the riches of his goodness and providential care on classes of animals and plants apparently so insignificant, and comparatively incapable of either enjoying or appreciating those bounties which he conferred upon them; while, on the other hand, the knowledge of his revealed attributes affords sufficient assurance, that whatever did then exist was that which was most consistent with those attributes; and that when the Creator beheld them labouring to accomplish his will in their dark and profound abodes he could have declared—although it has not pleased him to reveal it to us, that their work also "was good."

When treating, in the First Section, of the animal existences of that period, I made it very plain that by means of the corium and other secreting membranes, they fabricated to themselves coverings of carbonate of lime, cemented together by a small portion of animal gluten,* and, also, that their testaceous and zoophytic remains are of immensely greater dimensions than any belonging to recent equivalents. It is also acknowledged that the presence of the organized exuviæ proves, to a certainty, the existence at one time of the animal inhabitants, while the known relation of the animal to its covering, demonstrates their excess in size beyond any of their living congenors. That, besides the three elements, oxygen, hydrogen, and carbon, which plants and animals alike contain, the latter generally have more azote or nitrogen in their composition,"† and that these apulmonic animals and zoophytes, from either being fixed, or of restricted motion, were wholly dependent on the surrounding fluid for their sustenance.‡

Combining all these essential circumstances together, the clear deduction is, that the effect upon the primeval ocean of animal drainage alone, through numberless ages, was, *to abstract from its water a quantity of matter equal to the aggregate mass of their shelly coverings, and of those parts of the animal bodies which, after their death, did not re-enter into the circulation then going on.* And, lastly, that the elementary materials thus withdrawn from the primitive

* 136th Theorem.
† Animal Kingdom, by Baron Cuvier. Edinburgh. Preface to Nat. Hist. pp. 17, 18.
‡ Dr. Fleming's Work on British Zoology.

ocean, by animal chemistry and agency, consisted of carbonic acid (oxygen and carbon), and lime (calcium and oxygen), to form their testaceous and zoophytic coverings; and of carbon, oxygen, hydrogen, and azote to constitute their animal bodies.

With respect to the no less active and extended agency of *vegetation* in effecting the object now alluded to, sufficient has already been explained to show, that enormous cryptogamic and allied plants of different families abounded and were influential in producing the changes which took place throughout the whole period of non-rotation, and more especially during the formation of the coal series; and as analogy and the nature of their remains authorize us to consider their constituent elements to have been oxygen, hydrogen, and carbon; we may conclude that *for all of these, as well as for whatever they, through their roots, deposited in the soil, they must, from the very nature of the attendant circumstances, have been wholly dependent on the surrounding medium.*

In fine, it may be assumed, that there were abstracted from the primitive water, by vegetable agency and secretion, all the materials which constitute the carboniferous portion of the terraine formations; or, in more general terms, all that which went to form the submarine vegetation of the earth during the protracted period I allude to—less the elements which, after the plants were deprived of the principle of vegetable life, re-entered into circulation, and became parts of new combinations; while, to complete this conception, it should be kept in mind that, at the bottom of a deep and atmosphereless ocean, the gaseous exhalations which escaped from decaying plants would be infinitely less than under the circumstances which attend their decomposition in the present state of the earth.

The ultimate result of the combined secretions by animal and vegetable agency, *must have been to have abstracted from the* PRIMITIVE WATER *elementary materials equal to all the organic matter which owes its origin to these two sources*: a conclusion which is quite undeniable, and of which I shall avail myself hereafter by combining it with others, equally well substantiated.

The efficacy of the instrumentality thus brought to bear upon the universal menstruum, can only be sufficiently estimated when the vast extent and great depth of the aggregate deposits, which mainly owe their existence to animal and vegetable remains, are taken into account; and when the impression is properly borne in upon the mind of the efficiency of numbers, we might say of myriads, in combination, when they are substituted for *individual* power, however great.

To convey an adequate conception in a few words of the actual results of the means then employed is impossible; I shall, therefore, as usual, have recourse to concise extracts from the writings of those indefatigable men, who, by their researches, have done so

much for this branch of science, and have contributed so essentially to the elucidation of this part of the earth's history.

"The carboniferous limestone," says Sir Henry de la Beche, "in the South of England, Wales, the North of France, and Belgium, seems to possess a somewhat similar general character, being a compact limestone, frequently traversed by veins of calcareous spar, at times appearing to be in a great measure composed of organic remains, while at others not a trace of these remains can be observed.

"It is occasionally of an oolitic structure, and sometimes contains parts of encrinal columns in such abundance that the rock is, in a great measure, made up of them, whence the name *Encrinal Limestone*."*

"Some of the beds of the carboniferous limestone," writes Dr. Ure, "are so pure as to contain 96 per cent. carbonate of lime; but by foreign admixture it passes into magnesian, or ferruginous, or bituminous, or fetid limestone. Its beds are commonly very thick, extending in a continuous series many hundred feet in depth. Many species of testacea or shell fish begin to appear in the carboniferous limestone; but they, all along, belong to a very few genera; while the zoophytal families (polyparies), particularly encrinites and corallites, exist in the greatest abundance. . . . From the profusion of encrinites, this species of limestone has often been called encrinal. The coralloid remains are caryophylea, turbinolia, astrea, favocites, tubipora, and retipora."†

"It is a difficult problem," states Professor Buckland, "to account for the source of the enormous masses of carbonate of lime that compose nearly one-eighth part of the superficial crust of the globe. Some have referred it entirely to the secretions of marine animals; an origin to which we must obviously assign those portions of calcareous strata which are composed of comminuted shells and coral-lines; and, until it can be shown that these animals have the power of forming lime from other elements, we must suppose that they derived it from the sea, either directly, or through the medium of its plants. In either case it remains to find the source whence the sea obtained, not only these supplies of carbonate of lime for its animal inhabitants, but also the still larger quantities of the same substance that have been precipitated in the form of calcareous strata."‡

"The most prolific source," says the same author, "of organic remains, has been the accumulation of the shelly coverings of animals which occupied the bottom of the sea during a long series of consecutive generations. A large proportion of the entire substance of many strata is composed of myriads of these shells reduced to a comminuted state, by the long conitnued movements of water. In other strata the presence of countless multitudes of unbroken coralines, and of fragile shells, having their more delicate spines still attached and undisturbed, shows, that the animals which formed them lived and died upon, or near, the spot where these remains are found.

"Strata thus loaded with the exuviæ of innumerable generations of organic beings, afford strong proof of the lapse of long periods of time, wherein the animals from which they have been derived lived and multiplied, and died, at the bottom of the seas, which once occupied the site of our present continents and islands. Repeated changes in species, both of animals and vegetables, in succeeding members of different formations,

* Geological Manual.

† Dr. Ure's Geology, pp. 175—178.

‡ Bridgewater Treatise, vol. i. p. 89.

give further evidence, not only of the lapse of time, but also of further important changes in the physical condition and climate of the ancient earth."*

"Successions of strata, each many feet in thickness, and many miles in extent, are often half made up of the calcareous skeletons of encrinites. The entrochial marble of Derbyshire, and the black rock in the cliffs of carboniferous limestone near Bristol, are well-known examples of strata thus composed, and show how largely the bodies of animals have, occasionally, contributed by their remains to swell the volume of materials that now compose the mineral world."†

"The remains of organic existences," according to a late continental writer, "reveal to us that entire formations occur wholly composed of the fossil relics of animalculites. To Ehrenberg we are indebted for the development of the fact, that ages ago our world was rife with these minute organisms, belonging to a great number of species, whose mineralized skeletons actually constitute nearly the whole mass of some tertiary soils and rocks several feet in thickness, and extending over areas of many acres. The size of a single one, forming the polishing slate, amounts, upon an average, and in the greatest part, to one two-hundred-and-eighty-eighth of a line. As the Polerschiefer of Bilin is slaty, but without cavities, these animalcules lie closely compressed. In round numbers, about 23 millions would take up a cubic line, and would, in fact, be contained in it. There are 1,728 cubic lines in a cubic inch, and, therefore, a cubic inch would contain, on an average, about 41,000 millions of these animals. On weighing a cubic inch of this mass, I found it to be about two hundred and twenty grains. Of the 41,000 millions of animals, 187 millions go to a grain; or the siliceous shield of each animalcule weighs about a hundred and eighty-seven millionth part of a grain."

A modern author, who has given a great deal of attention to fossil remains, when treating of those of the silurian or first epoch, assures us, that

"Polyps—as animals of this low organization are called—appear to have been among the first of created beings, and are also those which are changed least up to this present time. . . . . . They seem to have been comprised within a very limited number of natural families, and some particular species probably extended through the whole number of beds of the first great epoch. . . . . During every successive period, from this their first appearance in the infancy of the world, to the present, these polyps have been adding to the solid matter of our globe by their singular buildings of stone. . . . . These little creatures are enabled to separate from the sea-water a proportion of carbonate of lime, used in constructing their stony encrustations; and they do this, although the quantity present is so minute as to be almost inappreciable by the most careful chemical analysis. . . . They secrete the calcareous or stony coverings on the outside of their soft bodies, and some of them form themselves into compounds resembling trees, with root, stem, and branches, composed of separate and detached particles. The *Encrinites*, *Sphæronites*, and *Pentacrinites* are remarkable examples of this, one individual of the former being made up of no less than 30,000

* Bridgewater Treatise, vol. i. p. 116.

† Ibid, pp. 416, 417.

separate particles of stone, while one of the latter contains 150,000 minute pieces of the same material."*

These extracts—a hundredth part merely of what might have been given—will, I trust, have sufficiently shown the attributed origin and construction of the calcareous formations, some of which underlie and admirably protect the coal measures. And when we contemplate these calcareous rocks in a more general, and at the same time, relative point of view, they will be found to exhibit, in a very remarkable manner, that wonderful wisdom so manifest in all the works of the Creator.

Besides the intrinsic and almost unlimited value of these mineral treasures to man, as a material subministering to his use and comfort, and as the chief repository of many of the metalliferous ores, the testacea and zoophyta, which, by their indurated remains contributed so essentially to the construction of the calcareous deposits, imparted, at the same time, from their molluscous parts, a peculiar ingredient which enters very materially into the composition of coal. In the calcareous formations were bound up, in a perfectly harmless condition—within the reach and at the will of man—noxious and superfluous gases, in union with earthy and insoluble bases, whereby the primitive water not only became cleansed of those life-destroying elements, but, hurtful as they are in themselves, they were also transformed into deposits of useful material for the wants of races destined afterwards to inhabit the Earth, and into solid barriers to restrain the ocean within the bounds assigned to it: a provision of gracious forethought, whereby these elements were rendered *always useful and innocuous* to the altogether different races of living beings which seem to have been destined to people the earth at successive periods of its creation.

No less admirable was the adaptation of the calcareous deposits in a *relative* point of view. In this respect, aided by aluminous admixture (the best non-conductor of heat among minerals), they performed the important office of a *great lining formation*, to defend the coal measures from the action of those intense heats which were engendered by the first rotation of the Earth; and which, without this almost impervious defence underneath the great body of the coal, would have driven off, by fusion, the essential bituminous portion, and left the extensive coal measures of the world as indurated, and perhaps, more unserviceable than the hardest anthracite; which, occurring in small portions at the points of contact and fusion, have left specimens of what would otherwise most probably, have been the inevitable result throughout the whole extent of the coal series.

And finally, the great underlying calcareous formation—marked by the bold caligraphy of fossilized remains—reveal to us by those enduring characters, which can neither be set aside nor misunder-

* Ancient World, by Ansted, pp. 27—31, 118, 119, 137.

stood, that ages before the principal accumulation of the vegetable remains which constitute the coal measures, the solid portion of this sphere teemed with animal life, with beings of apulmonic description, and of the kinds so elaborately classified by geologists, who have given their attention to the subject, and whose writings have afforded some of our most efficient evidences. To these I may have occasion to recur as I proceed with this discourse.

Now, wherever are found calcareous shelly coverings of an organic structure, *there* the animal fabricators and inhabitants must also, at some time, have been; but, existing no longer, they must, after death, have become subject to the all-pervading laws of decomposition and chemical affinity; consequently, in the progress of their decomposition, have given rise to those results which have been so well explained by the writers from whom I have so frequently and fully quoted. For, wherever the efficient causes were, there the results would inevitably follow.

In a former part of this work it was shown that there was a succession of inferior animal life in the primitive ocean; and if a succession, then an adaptation of being to the various changes which the water underwent.*

It may be well to have these facts present to the mind, while, amidst the difficulties which arise from the uncertainty that still prevails as to the sequence of and influence exercised by electro-chemical attraction when several ingredients are held in simultaneous solution; from the variations of temperature, and the unknown amount of these; and from the effects of the immensity of the body of the water employed, I endeavour, notwithstanding these formidable objections, briefly to explain how the several ingredients (many of which are of themselves insoluble in water) are considered to have been held in chemical suspension by the primitive ocean.

Silex, the most abundant of those earthy ingredients, is wholly insoluble in water in the state in which it is generally found deposited. Alumina, however, unites with it in the humid way, and renders silex soluble in acids, an effect which barytes also exercises over it.† Muriatic acid dissolves a small portion of it when finely comminuted; and fluoric acid dissolves it either when the acid is gaseous or when combined with water.‡ And, it is asserted, on the authority of Berzelius, "that when newly oxygenated it is extremely soluble."§ Without attempting to investigate when and how its base was, at first, brought into contact with oxygen, and thereby became oxygenated, I am authorized to infer, that being now in actual union, there was a time when it was "newly oxygenated," and that *then* it was soluble and impregnated with the gases mentioned above. At that time water must also have existed. A combination of these facts permits the fair conclusion that it may

* In accordance with the 135th Theorem. † Murray, vol. ii. pp. 71, 98.
‡ Ibid, p. 111. § Ibid, p. 108, and Dr. Ure, p. 743.

have been dissolved and remained soluble in the primitive water from the period of its having been newly oxygenated.

ALUMINA—the next abundant earth in nature—although of itself not soluble in any sensible degree in water, yet its compounds are soluble in every possible proportion. The salts of alumina, formed by its union with muriatic, carbonic, sulphuric, and nitric acids, especially the first, are all abundantly soluble in water. It is likewise rendered soluble by the fixed alkalies, and by barytes and strontites, and therefore its solubility in the water of the primitive ocean, where all those existed in profusion, is very easily accounted for.

MAGNESIA may be considered pretty much in the same relative circumstances as the last-mentioned earth; for although its carbonate requires two thousand times its own weight of water to dissolve it, yet, as the salts of magnesia arising from combination with either muriatic, nitric, or sulphuric acids are extremely soluble, there can be little difficulty in conceiving it to have been held in solution in its states of a muriate, or of a sulphate, and the less so when it is considered that in those combinations it still exists, to a certain degree, in sea water.

LIME, which, in respect to prevalence in the earth's crust, occupies the third place, is of itself rather insoluble in water, for this, at 60° of temperature, only takes up 1-656th part of its own weight. Its carbonate is also nearly insoluble, and its sulphates require nearly 500 times their own weight to dissolve them. But as a muriate and nitrate it is extremely soluble, and abounds in these states, especially the former, both in the waters of many springs and in the ocean; consequently its solubility in the primitive ocean must be readily admitted. *Lime* presents the remarkable anomaly of being less soluble in warm than in cold water; water at 60°, when the temperature is increased, deposits part of the lime which it could have sustained at the former degree.*

ZIRCONIA and GLUCINA—earths but sparingly found in nature—though not soluble when united with carbonic acid, yet are soluble when combined with either muriatic or nitric acids, consequently their solubility may be considered likewise established.

SODA and POTASH, fixed alkalies, possess great affinity for water, and are not only soluble in it themselves, but so, likewise, are the salts which they produce by combination with the acids above-mentioned. They materially aid the solubility of other substances, and in aqueous potash even the oxides of many metals, such as lead, tin, manganese, zinc, &c., become soluble—a fact which will greatly assist in following out this enquiry.†

The ACIDS are not only extremely soluble in water, but some of them are absorbed by it to the extent of many times its own bulk.‡

* Murray, vol. ii. p. 83. † Ure, p. 691.
‡ Hugo Reid, p. 108.

Muriatic and sulphuric acids act on the metallic oxides, and also form soluble salts of iron, copper, tin, and zinc; sulphuric acid forms one of manganese; and carbonic acid does the same with iron; and by this we are enabled to account for the solubility of those otherwise refractory substances.

Having thus summarily accounted for the solubility of those various ingredients in the primitive ocean, it next becomes necessary to attempt some explanation of the manner in which it is supposed they could have assumed such a state of equilibrium as would have required either some abstraction from, or addition to, the general menstruum, before any precipitate could have taken place.

Had the earthy substances which were employed in this vast laboratory all severally exercised the same degree of affinity for the acids there present, or reciprocally for each other, the state of equilibrium, so often alluded to, would have been utterly unattainable. The simple ratios of affinity of several of them, however, have been accurately ascertained, and are known to differ considerably.* It is, therefore, natural to suppose that, being all present simultaneously in the general menstruum, they would arrange themselves according to those affinities, until they had found their level, and attained those partial states of equilibrium from which no change could have taken place without some abstraction from or addition to the general mass.

The reasoning on this point will receive much confirmation when we reflect that the seas *have come* to a static condition of equilibrium; that they maintain this now in their normal or finished state, incapable of ever being again disturbed; while it is just as conceivable, that during the progress of their arriving at this ultimate stage of equilibrium, they may have passed through several intermediate stages of partial equilibrium, from which they could only have been aroused to renewed progress of purification that they might assume their ultimate state, by some such agency as has been alluded to. While the general though feeble affinity of water itself (the vastly predominant element in the whole mass) to one and all of those substances, which has been shown could, under certain forms, be held in solution in it, would greatly tend to perfect free-

* For example:—sulphuric acid has a greater affinity for baryta than for potash, for potash than for soda; while this latter alkali is succeeded in order by lime, magnesia, ammonia, and alumina. (Ure, p. 184.) *Lime* has a greater affinity for muriatic and sulphuric acids than for carbonic acid, while it exceeds either potash or soda in affinity for the latter. *Potash* has a greater affinity for water, for carbonic acid, and indeed for all examined substances, than *soda* has. Soda exercises a greater preference for carbonic than for muriatic and sulphuric acids. (Ibid, p. 756.) The fixed *alkalies* neutralize all the salts of ammonia, while this, in turn, neutralizes nearly all those of alumina. (Ibid, p. 141.) *Ammonia* has also greater affinity for carbonic than for muriatic acid. Muriatic, nitric, and sulphuric acids, together with aqueous potash, act on the metallic oxides; and the alkaline earths, when combined with carbonic acid, are insoluble, although the alkalies themselves, when so combined, are soluble.

dom of motion amongst the variously relationed elements, and admit of their uniting with facility according to their several affinities.

At the same time it should be remembered, that the gaseous elements now composing the atmosphere, were, as yet, incorporated with their parent water, and would confer upon this latter vastly increased facility to solve and to retain other ingredients.

It is only necessary now to repeat the example formerly given of water—even in the present day, with infinitely reduced powers of solution and absorption—holding in simultaneous combination ingredients somewhat similar to those which are considered to have existed in the primitive ocean, namely, the mineral water of Carlsbad, which is found to consist of sulphate, carbonate, and muriate of soda; carbonate, fluate, and phosphate of lime; carbonate of strontia; carbonate of magnesia; phosphate of alumina; carbonate of iron; carbonate of manganese; and silica.*

Let it be supposed, therefore, that the primitive ocean, charged with earthy, alkaline, and gaseous elements, had assumed one of those stages of partial equilibrium; and that no further deposition could have taken place until either some abstraction from, or some addition to, the general mass had been made. A *spontaneous alteration*, it has been shown by reference to the law of inertia, *could not possibly have occurred*, and it was, therefore, indispensable that an agency, possessing powers independent of inertia, should be employed; or, in other words, that the universal menstruum should be acted upon either by crystalization, or by the principles of animal or vegetable life; *consequently, in either of these latter cases requiring a specific act of creative power*. Presuming the intention to have been to tenant the bottom of this immense laboratory with innumerable animated agents endowed with faculties adapted for absorbing, decomposing, assimilating, and re-combining the elements which were suspended in the universal menstruum, whereby many of these elements became locked up; the results alluded to, all alike dependent on animal energy, would naturally ensue during their lifetime; and after their death, the elements so absorbed and elaborated would be restored to the water in modified combinations, and with certain peculiar additions which animal secretion alone could bestow upon them. Thus there would be a continual and an intricate circulation maintained in the primitive ocean from as many points, along the whole extent of its base, as there were mouths and stomatæ in the aggregate of its testaceous and polypiferous inhabitants, and its vegetable existences. It appears, also, from undoubted evidence, that those operations were carried on by a succession of races, each adapted to the surrounding media of its day, and that they were continued in a similar manner through many ages, whose duration, together with the multiplicity of points and currents, would amply

* Annals de Chim. xxi. p. 248.

compensate for the small amount of work accomplished by each individual agent, and the minuteness of many of those employed.

In order to simplify the subject as much as possible, I have, in the foregoing, alluded chiefly to the effects of inferior *animal* life; but the reader should remember that a succession of events and effects precisely analogous were almost simultaneously taking place by means of the vegetative functions of imperfect orders of *plants*, of which it will be necessary to treat more especially in the sequel.

Meantime, it should be observed, that in very many instances the fossil testacea and conchifera greatly exceeded in size many of their recent equivalents, and that entire calcareous formations are composed almost wholly of encrustations of the exuviæ of testacea and conchifera, whose coverings consisted of carbonate of lime amassed together by animal gluten.

It has also been explained, that carbonate of lime is composed of carbonic acid and lime, insoluble in water in their combined state, consequently, by means of the universal carrier, water, and the constraining animal agency referred to, those two ingredients—one of which in large volumes is very injurious to animal life—became reciprocally bound up; were rendered innocuous to the more perfect races which were afterwards to follow; and were stored up for the future uses of man, whose intelligence alone could disunite and apply them to his own purposes.

Significant as this is of the unbounded goodness of Providence in providing for his creatures, it was not with this view alone of the case that the attention was directed to the fact, "*that the shelly coverings of those testaceæ and conchiferæ were composed of carbonic acid and lime, forced into union by their animal chemistry and elaboration,*" but to bring out another very striking manifestation of the wisdom which pervaded the whole work of creation. According to the well-ascertained affinity which lime exercises towards the various acids known to have existed in the primitive ocean—there is none with which it would not *sooner have spontaneously united, than with carbonic acid;* and, consequently, had the constituent elements been allowed to combine as their affinities would have induced them, it is evident that so long as there remained within a combining distance, an unappropriated volume of muriatic, nitric, sulphuric, or, indeed, any other acid, no spontaneous combination between lime and *carbonic* acid would have taken place. *No carbonate of lime would have been formed.* In order to separate lime from its combination with muriatic, nitric, or sulphuric acid, to which it has so strong an affinity, and cause it to combine with carbonic acid, *the application of a force beyond chemical affinity was essential,* and that power was provided, by the faculty having been conferred on the testacea, conchifera, and zoophyta, to abstract those elements from the surrounding medium, and to elaborate them into carbonate of lime, to constitute their calcareous coverings. The fact, itself, of their union has been

established beyond a doubt.* The motive which induced the Creator so to order the chemical affinities that this animal agency should be indispensable, may not, at first sight, be quite so apparent; but when we submit, in our researches, to a constraining conviction of the fitness of the means adopted, on all occasions, by the Omnipotent, to the end which He has in view; and bring to mind the perfection of the attributes which, in union, guide His determinations, we shall be ready to confess that beneficence towards His creatures must have prevailed throughout the whole.

When we are made aware of the importance, in the development of the plan of Creation, of certain elements which appear to have been capable of being produced only by animal secretion; and remember the necessity of the elaborators being provided with coverings of some hard material insoluble in water, to protect their molluscous bodies from the pressure of the ocean; and add to these that, while assiduously working out the Creator's will, they were enjoying all the pleasure of which their restricted powers and inferior animal life were susceptible, a clear glimpse is obtained, faint though it be, of some of the motives which seem to have induced their being called into existence, and employed for ages to do the Creator's work at the bottom of the primitive ocean; while their comparative fixity, and limited degree of animal sensation, adapted them more peculiarly to the situation they held, and fitted them for the labour they had to perform.†

If it were admitted, that in some relative positions of the associated elements held in solution by the primitive waters, *lime* would be more difficult of abstraction, that is, that it was kept in firmer affinity by some of the acidulous states of the ocean, than at other times, and by other states of it, then we might thereby easily account for the succession, in many instances apparently *gradual* changes of animal life; it being necessary under these circumstances, in order to carry on the work in progress, that there should have been formed new races of creatures, possessing greater powers of abstraction than their predecessors, and better adapted to overcome the greater resistance which lime evinced to separate itself from its acidulous associates.

Neither should it be altogether overlooked, that even although

* A competent and impartial authority has stated that the polypiferous and molluscous inhabitants of the ocean possess the faculty of abstracting lime from the surrounding briny element, even though it should exist only in proportions so minute as to escape the most searching chemical test; and we have also seen that they can elaborate it into particles of such tiny proportions, that hundreds of thousands of them are required for the construction of an animal not larger than a usual sized lily.

† I am not without motives for conjecturing that during the period of non-rotation the Creator was causing to be elaborated, besides those parts more discernible by our senses, the materials which, in due time and by His sovereign mandate, should constitute the etherial fluid, or primitive light, to be "stretched forth as a curtain," when the other parts of the wonderful work were in a suitable condition to be combined with, and acted upon, by this second all-pervading law of materialism.

they had been supplied with the nutriment they required, death would frequently be taking place amongst those mollusca and zoophyta;* and that the gaseous exhalations which, as will be seen more particularly in the sequel, arising therefrom, would, by separating certain earthy elements from others with which they were associated, cause the deposition of as much earthy and metallic bases as those gaseous exhalations were capable of releasing and precipitating. The *small* continued doses of ammonia, arising from the decomposition of their bodies, and ascending by its lighter specific gravity, would also contribute more effectually to this than if those exhalations had been more abundant; for more powerful doses of ammonia are found to re-dissolve the precipitate.†

Without tarrying at present to enquire into the cause of the progressive increase of the temperature of the primitive ocean, but assuming this to be a fact established beyond a doubt,‡ I shall apply it to a point equally well ascertained in chemistry, namely, that water, when heated beyond 60° of Fahrenheit, deposits part of the lime which it can hold in solution at that degree of the thermometer. Or, in other words, "that lime possesses the remarkable anomaly of being less soluble in warm than in cold water." This may, perhaps, in part account for what has hitherto appeared so inexplicable, namely, the increase of calcareous formations, up to a certain point, according as they approach the present era, lime abounding more in the upper than in the lower formations. Agreeable to the laws which regulate animal functions and life, its gradual and progressive increase will, most probably, account for the remainder of this excess of lime in the newer, when compared with the older series of rocks; while, what has been said on the subject, altogether, may serve as an imperfect indication, and point the way to a more successful explanation of the manner in which the whole of the GREAT CARBONIFEROUS LIMESTONE SUIT may have been formed.

As a suitable illustration of this I may quote what Professor Phillips says regarding the "deposition of the oolitic system:"—

"The concretionary structure of these limestones is imitated in modern times only in situations where carbonate of lime is separated from chemical solution in water (Carlsbad). If we ascribe this origin to the oolitic sediment, the concretionary aggregation of the particles may be understood as

* It will be observed that I assume *death* or *extinction of animal life* to have been a prevailing law during the period of non-rotation, ages prior to the Mosaic week. Occular demonstration, arising from the every-where abounding exuviæ of living forms, convinces us of this. I have, besides, the authority of sound inference to lead me to the same conclusion; for had our first parents not understood the full signification of the denouncement contained in the words, "in the day thou eatest thereof thou shalt surely die," this gracious warning of their contingent doom would not have been made use of to exercise that salutary influence for which it was evidently designed.

† Attraction, Dr. Ure's Chemical Dictionary.

‡ See 36th Theorem and proofs.

arising from molecular attraction in the mass, and, in fact, many of the sporules of oolite contain an internal nucleus of previously solidified matter, a small shell, a grain of sand, or somewhat else, capable of determining the condensation of the particles to particular centres; just as the matter of iron stone has collected into nodules round a fish scale, a piece of fern branch, or a shell."*

As there were no attendant circumstances in the *then* condition of our sphere to render what was applicable to one place inapplicable to another, the same causes would, of necessity, everywhere produce the same effects simultaneously, the encrustation of the bottom of the ocean in those localities which it pleased an omniscient Creator should be so prepared, in perfect harmony with the development of His plans, and for the future benefit of His creatures.

It was formerly explained at considerable length, that the researches which have been made into the state of the ancient fossil remains, reveal, in the most unequivocal manner, that there has been a succession of inferior animal life during those early geological epochs; and it was attempted to be proved, that as these successive generations were wholly dependent on the surrounding medium for their food, and matter for their coverings, each race must have become extinct when those peculiar substances, which it required, had, by drainage, been exhausted from the surrounding element. In the subject which has more immediately occupied the attention, a glimpse was obtained of some of the more prominent uses to which these testacea, conchifera, and zoophyta were made subservient by their agency during the course of their fixed and tranquil life. And it will now be requisite to show, that by their death—which, for the reasons already given, has been assumed as a matter of fact—they also contributed in a singular manner to the development of the great plan of creation. With this view I shall first unfold the phenomena which attend the decomposition of animal matter.

"When," in the expressive language of Dr. Fleming, "the vital principle has deserted the body which it had constructed, and surrendered it to the influence of the laws of inorganic matter, then, in obedience to the power of gravitation, the pliant twig hangs down, and the slender stem bends. In animals, the body falls to the ground; the pressure of the upper parts flattens those on which the others rest; the skin stretches; and the graceful rotundity of life is exchanged for the oblateness of death. The laws of chemistry then appear to operate in the production of the cadaverous smell, the prelude to putrefaction, when dust returns to dust."†

Messrs. Todd and Bowman confirm this, when they say—

"While these substances (those of animal bodies) retain a perfect organization, and are supplied with their proper stimuli, vital actions go on without interruption, and no change takes place in the matter of the organism excepting such as result from its proper affinities. But no sooner is the

* Treatise on Geology, pp. 147, 148. † Philos. of Zoology, vol. i. p. 39.

integrity of its structure destroyed, or the influence of the vital stimuli withdrawn, than action ceases, the organism dies, and the organic matter yields up its elements to form new compounds, a large proportion of which are inorganic."*

By the *hundred and thirty-ninth* Theorem it will be seen, "*That on the decomposition of animal substances taking place, when moisture and a certain degree of heat are present, putrefaction commences, the elements of the animal matter enter into new combinations, and generally pass off in the gaseous form; ammonia being always disengaged in considerable quantity: phosphuretted, sulphuretted, and carburetted hydrogen, and carbonic acid, are likewise separated, and only an inconsiderable portion of earthy matter remains when the process is finished.*

"When the putrefaction of animal substances commences," Dr. Murray states, "their elements enter into new combinations, which generally pass off in a gaseous form; and only an inconsiderable quantity of earthy matter remains when the process is finished. A certain temperature is necessary to this process; below 32° it appears to be arrested, as is evinced by the bodies of the mammoth and rhinoceros found in ice blocks on the northern shores of Siberia, perfectly unaltered, though they must have lain there from a time anterior to all history. The air does not seem essential to putrefactive changes by chemical action, but a communication with the atmosphere is favourable, by allowing the elastic products to escape. The precise nature of these combinations has not, from the offensiveness of the process, been accurately observed, and they probably vary according to the nature of the animal matter, and the circumstances under which it is decomposed. *Ammonia*, formed by the union of the nitrogen and hydrogen of the animal matter, is always disengaged in considerable quantity. Phosphuretted hydrogen appears to be produced; and to this gas the odour termed putrid is chiefly owing. Sulphuretted hydrogen occasionally forms another part of the vapours disengaged from putrefying substances, as they have often, in some degree, its smell, and blacken the metals, a peculiar property of this gas. Carburetted hydrogen and carbonic acid are likewise separated, and it is probable that not only these binary combinations, but also compound gases, consisting of three or more of these elements, with oxygen, are formed and discharged.

"Putrefaction is the great process employed by nature to restore the elements of matter to simpler forms of existence, and to prepare them again to pass through new series of combinations. Being necessarily carried on at the surface of the earth, its products are diffused through the atmosphere, dissolved by water, and absorbed by the soil: they furnish the principal nutritious matter for the support of vegetables, and are thus again adapted to the nourishment of animals."†

"Like vegetables," says Mr. Reid, "animals, as soon as the vital principle has departed from them, are solely obedient to the laws of chemistry; they lose their form and entirely *disappear*, the elements of which they are composed enter into new states of combination, and they *decay or rot*, partly mixing with the air as transparent invisible gases, and partly crumbling

* Physiology and Anatomy of Man, p. 15.
† Murray's Elements of Chemistry, vol. ii. pp. 676, 677.

down to powder, which, mixed with, cannot be distinguished from, the surrounding earth.

"From the presence of nitrogen, ammonia is formed during their putrefaction. *Ammonia* consists of hydrogen and nitrogen, as formed during the decomposition of animal substances; it is in union with carbonic acid in the state of *carbonate of ammonia*. Carburetted hydrogen, and small quantities of two other compounds of hydrogen (sulphuretted hydrogen, and phosphuretted hydrogen gases), are formed during the decomposition of animal matters. The chief products of the decomposition are water, carbonic acid, and carbonate of ammonia. . . . . . The bones and shells of animal bodies, on account of the earthy matter which they contain, endure for a very long period; but, gradually, as the animal matter or cement is decomposed, and separated from the earthy matter, also moulder away, and mix with the surrounding earth."*

"Ammonia," says Dr. Murray, "is always produced by indirect processes. Its ultimate source is usually from the decomposition of animal matter, of which its constituent principles are elements, and which, in the new combinations taking place in that decomposition, unite so as to form it."†

"In consequence," Dr. Fleming observes, "of this difference of composition, all vegetable matters may be easily distinguished when burning; the odour of each is so peculiar that the test may be safely employed by the most inexperienced. Besides, as vegetables abound in oxygen, they have a tendency, after death, to become acid by its new combinations with carbon and hydrogen; whereas the soft parts of animals, after death, are disposed to become alkaline, the azote entering into new combinations with the hydrogen, and forming *ammonia*."‡

"Organized bodies," say Messrs. Todd and Bowman, "are found in two states or conditions, life and death. . . . . That of *death* is one in which all vital action has ceased, and to which the disintegration of the organized body succeeds as a natural consequence. . . . . . .

"Such bodies are also capable of being resolved by chemical analyses into the inorganic simple elements, but comprising only about seventeen.

"Of the widely-spread elements, oxygen, hydrogen, nitrogen, and carbon, two, *at least*, will be found in every organic compound; and these four, as Dr. Prout has suggested, may therefore be called the *essential* elements of organic matter. The other simple substances are found in smaller quantities, and are less extensively diffused; these may be termed its *incidental* elements. They are sulphur, phosphorus, chlorine, sodium, potassium, calcium, magnesium, silicon aluminum, iron, manganese, iodine, and bromine; the last two are obtained almost exclusively from marine plants and animals."§

In order to preserve that continuity of thought which is so essential in close reasoning, I have confined myself to a succinct account of the usual results of *animal* decomposition. One of the principal exhalations arising therefrom is *ammonia*, which originates in the combination of hydrogen with the nitrogen of animal secretion.

* Chemistry, by Hugo Reid, p. 181.
† Murray's Elements of Chemistry, vol. ii. p. 11.
‡ Philosophy of Zoology, vol. i. p. 41.
§ Physiology and Anatomy of Man, pp. 4—6.

But ammonia, introduced into a compound, in which the salts of alumina are held in solution, throws down their earthy base, even although acidulated with muriatic acid.* Consequently, as the decomposition of animal substances would assuredly create ammonia, its low specific gravity would cause it to ascend and enter in amongst the other ingredients in the compound solution held by the primitive ocean, whilst its introduction would precipitate alumina. Again, it is asserted by M. Berthollet, whose authority is of great weight in all matters relating to experimental chemistry, that "whenever an earth is precipitated from a saline combination by an alkali, it will carry down along with it a portion of its acid associate."† These truths should be kept present to the mind, for I shall have occasion for them presently in the further illustration of this subject. It is also deserving of notice, that the moderate doses of ammonia which would, from the nature of the circumstances, be introduced into the menstruum, would greatly aid the operations then going on.

Ammonia would exercise the same influence over whatever zirconia and glucina was held, at the time, in solution, for it also precipitates their earthy bases, and may account for the occasional presence of these scanty earths in the rocky masses of the globe; while Barytes and Strontites, in their several soluble states, aided the solubility of alumina; and they would, by the deposition of the latter, be left disengaged to act wherever their natural affinities thereafter induced them.

Barytes, strontites, and lime, by the attraction they exercise towards silex, would cause the latter to separate from its solution in potash;‡ and, according to the phenomena above-mentioned, to carry down a part of its associate; while a simultaneous precipitating influence would be brought to bear on silex by ammonia depositing alumina. Alumina being no longer present to aid the acids in dissolving silex, that flinty earth would be discharged in a ratio proportioned to the deposition of the other; and these two concurring causes, the one positive, the other negative, will, to a certain extent, account for the simultaneous deposition of silex and alumina, two earthy substances which enter chiefly into the composition of all clays. But yet, it is evident, that these causes are by no means sufficient to account for the great preponderance which silica has in almost every formation, especially in the aluminous strata, whose principal ingredient it is. *Silica* being a substance so difficult of solution, and so recondite with respect to the agents capable of acting upon it, I am prone to suppose that some other causes beyond those stated were present in effecting its deposition; while, at the same time, it is well known that electrical currents would effect what otherwise is so difficult to be accounted for; and as I do not doubt the existence of electrical currents, they are looked upon as

* Ure, p. 141, and Murray, p. 82. † Ure, p. 186. ‡ Murray, p. 111.

the efficient cause for the preponderance of the siliceous elements alluded to.

It has been shown that lime exercises a stronger affinity for carbonic acid than magnesia;* while both barytes and strontia possess stronger affinity than lime does, certainly to sulphuric, and perhaps to muriatic acid.† Carbonic acid enables water to hold carbonate of magnesia in solution. Alumina, by the affinity it exerts towards magnesia, aids its precipitation from saline compounds; and ammonia assists to precipitate magnesia from its solution.‡ Combining these truths, we have the following:—1. That the abstraction of carbonic acid from the water would cause the precipitation of the carbonate of magnesia. 2. That the more powerful affinities of the other earths for the acids mentioned, by preventing this alkaline earth recombining with them, would tend to the same result. Lastly, that the free alumina, in subsiding, by the affinity which it has to magnesia, would carry a part down along with itself; the introduction of ammonia would effect the same results. And these combined causes afford a sufficient explanation for the presence of magnesia; while a varying intensity in the activity and quantity of the efficient causes, may, perhaps, be sufficient to explain the difference in the proportions observable in the several minerals of which this porous earth forms a part.§

It has already been shewn how the metallic oxides are capable of being solved, and held in suspension by the primitive fluid; and it only remains now to endeavour to explain the process by which they were precipitated from it. To do this recourse must be had to another of the principal binary compounds, which, according to the scientific writers formerly quoted, results from the decomposition of animal matter; namely, phosphuretted hydrogen, which, in general *parlance*, precipitates metals from metallic solutions.|| While confining these general assertions to particulor cases, it can be said, that it throws down iron from the salts of that metal,¶ and also from that of manganese. Ammonia, likewise, precipitates iron, manganese, and other metals from their watery solutions.** But all of these precipitates must yield the palm to the electrical influences acting in aqueous currents, which have been found to be peculiarly adapted, not only for crystalizing those and other metals, but also for disposing them in nodules, or small detached masses, for Mr. Fox justly observes, that "copper, tin, iron, and zinc, in combination with the sulphuric and muriatic acids, being very soluble in water, are in this state capable of conducting voltaic electricity."†† Iron, it would appear, is generally found as an oxide intermixed with argillaceous, calcareous, and siliceous earths.‡‡

* Ure, p. 585. † Ibid, p. 184. ‡ Murray, p. 89.
§ Murray, pp. 82, 380. || Ure, p. 681. ¶ Murray, vol. ii. p. 210.
** Literary Gazette for 7th May, 1836, p. 296. †† Murray, pp. 380, 381.
‡‡ Murray, p. 197.

Sulphuretted hydrogen, another of the binary compounds arising from animal decomposition, possesses the property, when in union with sulphur and the alkalies, of forming very variable triple combinations.* Carburetted hydrogen, which is the remaining exhalation, seems, under certain circumstances, to deposit carbon, leaving the hydrogen free. It also possesses the peculiarity of impeding the union of oxygen and hydrogen, and other gases having an affinity for oxygen. When brought into contact with muriatic acid, it combines and produces an oily-looking compound of considerable specific gravity. The respective bases of these two gases can be made to produce an interesting fluid compound, called carburet of sulphur,† which, when introduced, together with potash and water, into metallic solutions, causes precipitates of a peculiar kind, called carbo-sulphurets.‡

The remaining binary exhalation from the decomposition of animal substances after death, is carbonic acid. When it is considered how essential this is towards the growth and nourishment of the plants which were about to be brought into existence, we cannot but admire the wonderful wisdom and providential care of the Deity, who thus provided, beforehand, for every successive step in the work of creation.

* Dr. Ure's Dictionary, p. 777. † Ibid, p. 778. ‡ Ibid, p. 307.

SECTION III.

DEPOSITION OF THE STRATA DURING THE NON-ROTATORY PERIOD.

CHAPTER XI.

The consequence of the introduction of any new element into chemical compounds of numerous ingredients. Evidences to show that clays, sandstones, and shales are composed of the same materials, which are assumed to have been held in solution by the primitive ocean. Chemical agency in the formation of the Old Red Sandstone. Geological evidence for the existence of extensive stratified masses of clays, sandstones, and shales underneath the Coal Measures. The succession of animal life during the period alluded to clearly deduced from the progressive change of the primitive ocean, and confirmed by the results of geological research. Wisdom of the arrangement which placed calcareous strata underneath the coal deposits, and between the latter and the igneous rocks which were ejected, amidst such intense heat, arising from the friction occasioned by the protorotation of the earth around its axis.

Before commencing the principal subject of this chapter, the attention should be directed for a moment to an important feature in all chemical compounds in which a variety of substances are held in combination. I allude to the change produced on the whole by the introduction of any new element. The greater affinity manifested by the introduced substance for some of the original elements causing these to abandon their former associates, in order to unite with it; while this, in turn, paves the way for other similar rearrangements amongst the remaining ingredients, although no direct influence may, or indeed could, have been exercised over these latter by that which has been added to the compound. Changes such as are now referred to in the nature of the binary or ternary compounds, of which the mass consists, have the effect of altering the equilibrium of compatibility, and producing such a state of incompatibility as may occasion the precipitation of whatever is requisite to restore the mass to a condition of equilibrium. For full information respecting substances which cause incompatibility, I beg to refer to the table given by Dr. A. Ure in his Chemical Dictionary, page 815, a perusal of which will convey a more perfect conception of what is desired, by this advertency, to impress upon the mind.

It may, perhaps, tend to simplify the general question, were it made quite apparent, that the elements of the clays, sands, and shales which were formed during the period to which I now allude, correspond with the character of the precipitates supposed to have

been discharged from the primitive fluid by the causes referred to. This will be best accomplished, perhaps, by giving the analysis of these several earths by writers who have treated the subject chemically.

"*Kaolin*, or *porcelain* earth," according to Dr. Ure, "consists of 52 per cent. of silica, 47 of alumina, and 0.33 of oxide of iron. *Potter's clay* contains 63 of silica, 16 of alumina, 1 of lime, 8 of iron, and 10 of water. Another analysis of the same gives 63.5 of silica, 33 of alumina, and 3.5 of lime. *Adhesive slate* is composed of 62.5 silica, 9.5 alumina, 8.0 magnesia, 0.25 lime, 4.0 oxide of iron, and 14 water. *Common clay* 1.0 of silica, 31 of alumina, 0.5 lime, 21.5 sulphuric acid, and 45.0 water. *Clay slate* 48.6 of silica, 23.5 of alumina, 1.6 magnesia, 11.3 oxide of iron, 0.5 of manganese, 4.7 potash, 0.3 of carbon, 0.1 sulphur, and 7.6 of water."*

"Aluminite," says the same author, "consists of sulphuric acid 19.25, alumina 32.5, water 47.0, silica, lime, and oxide of iron 1.25."†

"The term clay," observes Dr. Murray, "is ambiguous, but is applied to those earthy mixtures, more or less indurated, which imbibe water, and may be kneaded into a paste somewhat ductile. Alumina is the base of all of them, and gives this predominating character; it is mixed with various proportions of silex, magnesia, lime, and oxide of iron. Clay slate, as found by Kirwan, is composed of silex 38, alumina 26, magnesia 8, lime 14, and oxide of iron 14."‡

These results, it will be observed, very closely agree with what was anticipated would take place, from the introduction of the peculiar exhalents of decomposing animal substances into a general menstruum, holding alumina, silex, lime, magnesia, potash, soda, oxides of iron and manganese, and several acids in solution. It seems, therefore, almost impossible for any unprejudiced mind to contemplate this perfect coincidence without feeling convinced *that deposited strata corresponding to these characters would necessarily be the result.* Indeed, we must either come at once to this conclusion, or for ever abandon all faith in the true meaning of words, or in the results of scientific experiments. After having endeavoured to explain how some of the remaining earths were thrown down, I shall close the evidence on these particular points, by proving, from the experience of geologists, that rocky masses of corresponding character do really exist precisely where, as the direct effects of these causes, they might most naturally have been sought for.

Although hitherto I have not alluded to the ocean having contained nitric acid; yet as it held in solution the elements of which this is formed, viz., oxygen and nitrogen, it is perfectly legitimate to suppose that they *did* combine in such proportions as to form that powerful acid. It has been assumed that baryta and strontia were held in solution in the ocean, and assisted to cause the solubility of other substances; and, if they were so held in solution, they must

* Ure, pp. 331, 332. † Ibid, p. 146.
‡ Murray's Elements, vol. ii. pp. 311, 312.

have been in union with muriatic and nitric acids, in which states alone they present soluble compounds.

It will be remembered that a list was exhibited of the comparative affinities, given by Dr. Ure, of several substances with sulphuric acid, in which baryta predominated over all the others; but as strontia possesses properties and affinities very similar to the latter earth, it may be conjectured that each of these would rob the other enumerated substances of their sulphuric acid. Again, baryta and strontia exercise very strong affinities for carbonic acid, and would, when both were free, combine with it. But baryta and strontia, in union with the carbonic and sulphuric acids, form some of the most ponderous and less soluble of the earthy minerals; and consequently, they would, on assuming these combinations, be precipitated from the general menstruum. That such was actually the case it is considered will be sufficiently proved by the following quotations:—

"*Baryta*," says Dr. Ure, "is divided by Dr. Jameson into the four following species, viz.:—

"1. *Rhomboidal Baryta, or Witherite.* A carbonate of baryta, with occasionally 1 per cent. of carbonate of strontia, and sulphate of baryta. It occurs in Cumberland and Durham, in lead veins which traverse a secondary limestone, and rest on the red sandstone; its specific gravity is 4.3.

"2. *Prismatic Baryta, or Heavy Spar.* Of this there are nine sub-species. . . . . . They are all sulphates of baryta in composition. . . . . . Specific gravity 4.1 to 4.6. In Great Britain they occur in veins of different primitive and transition rocks, and in secondary limestones, &c., in the lead mines of Cumberland, Durham, and Westmoreland.

"3. *Diprismatic Baryta, or Strontianite.* Its constituents are

"Strontia	61.20	69.5	62.0	74.0
Carbonic acid	30.30	30.0	30.0	25.5
Water	8.50	0.5	8.0	0.5
	100.00	100.0	100.0	100.0

"Its specific gravity is 3.7, and it occurs at Strontian, in Argyllshire, in veins that traverse gneiss, along with galena, heavy spar, and calcareous spar.

"4. *Axifrangible Baryta, or Celestine* is a sulphate of strontia, with about 2 per cent. of sulphate of baryta. It occurs in trap tuff, in the Calton Hill at Edinburgh, and in the red sandstone at Inverness. It is abundant in the neighbourhood of Bristol. Specific gravity, 3.9."*

Besides these four species of baryta, in which there are occasional admixtures of strontia, these two earths unite together and form a mineral called *Barystrontianite* or *Stromnite,* of which Dr. Ure gives the following account:—

"It is composed of carbonate of strontia 68.6, sulphate of baryta 27.5, carbonate of lime 3.6, and oxide of iron 0.1, and is found in veins, or rather nests, accompanied by galena, at Stromness. Specific gravity 3.7."†

* Ure's Chemical Dictionary, pp. 518, 519. † Ibid, p. 200.

In continuation, the following passage from the "Old Red Sandstone," although somewhat long, yet is so interesting, indicates so clearly the difficulties of the case, and alludes to so many of the causes in operation during the deposition of the non-rotatory period, that I appeal to it with satisfaction, and am persuaded it will be perused with pleasure :—

"The chemistry of the old red sandstone formation," says Mr Miller, "seems scarcely inferior in interest to its zoology; but the chemist has still much to do for geology, and the processes are but imperfectly known. There is no field in which more laurels await the philosophical chemist than the geological one. I have said that all the calcareous nodules of the ichthyolite beds seem to have had originally their nucleus of organic matter. In nine cases out of ten the organism can be distinctly traced; and in the tenth there is almost always something to indicate where it lay—an elliptical patch of black, or an oblong spot, from which the prevailing colour of the stone has been discharged, and a lighter hue substituted. Is the reader acquainted with Mr. Pepy's accidental experiment, as related by Mr. Lyell, and recorded in the first volume of the *Geological Transactions?* It affords an interesting proof that animal matter in a state of putrefaction proves a powerful agent in the decomposition of mineral substances held in solution, and of their consequent precipitation. An earthen pitcher, containing several quarts of sulphate of iron, had been suffered to remain undisturbed and unexamined in a corner of Mr. Pepy's laboratory for about a twelvemonth. Some luckless mice had meanwhile fallen into it, and been drowned; and when it at length came to be examined, an oily scum, and a yellow sulphureous powder, mixed with hairs were seen floating on the top, and the bones of the mice discovered lying at the bottom; and it was found that over the decaying bodies the mineral components of the fluid had been separated and precipitated in a dark-coloured sediment, consisting of grains of pyrites and of sulphur, of copperas in its green and crystaline form, and of black oxide of iron. The animal and mineral matters had mutually acted upon one another; and the metallic sulphate, deprived of its oxygen in the process, had thus cast down its ingredients. It would seem that over the putrefying bodies of the fish of the lower old red sandstone, the water had deposited, in like manner, the lime with which it was charged; and hence the calcareous nodules in which we find their remains enclosed.

"The form of the nodule almost invariably agrees with that of the ichthyolite within: it is a coffin in the ancient Egyptian style. Was the ichthyolite twisted half round in the contorted attitude of violent death? the nodule has also its twist. Did it retain its natural posture? the nodule presents the corresponding spindle form. Was it broken up and the outline destroyed? the nodule is flattened and shapeless. In almost every instance the form of the organism seems to have regulated that of the stone. We may trace in many of these concretionary masses the operations of three distinct principles, all of which must have been in activity at one and the same time. They are wrapped concentrically each round its organism; they split readily in the line of the enclosing stratum, and are marked by its alternating rectilinear bars of lighter and darker colour; and they are radiated from the centre to the circumference. Their concentric condition shows the chemical influences of the decaying animal matter; their fissile character and parallel layers of colour, indicate the general deposition which

was taking place at the time; and their radiated structure testifies to that law of crystaline attraction, through which, by a wonderful masonry, the invisible, but well-cut atoms build up their cubes, their rhombs, their hexagons, and their pyramids, and are at once the architects and the materials of the structure which they rear.

"Another and very different chemical effect of organic matter may be remarked in the darker-coloured arenaceous deposits of the formation, and occasionally in the stratified clays and nodules of the ichthyolite bed. In a print-work the whole web is frequently thrown into the vat and dyed of one colour; but there afterwards comes a discharging process: some chemical mixture is dropped on the fabric; the dye disappears wherever the mixture touches; and in leaves, and sprigs, and patches, according to the printer's pattern, the cloth assumes its original white. Now, the coloured deposits of the old red sandstone have, in like manner, been subjected to a discharging process. The dye has disappeared in oblong or circular patches of various sizes, from the eighth of an inch to a foot in diameter; the original white has taken its place; and so thickly are these speckles grouped in some of the darker tinted beds that the surfaces, where washed by the sea, present the appearance of sheets of calico.

"The discharging agent was organic matter; the uncoloured patches are not mere surface films, for, when cut at right angles, their depth is found to correspond with their breadth, the circle is a sphere, the ellipsis forms the section of an egg-shaped body, and in the centre of each we generally find traces of the organism in whose decay it originated. I have repeatedly found single scales in the ichthyolite beds surrounded by uncoloured spheres about the size of musket bullets.

"It is well for the young geologist carefully to mark such appearances—to trace them through the various instances in which the organism may be recognised and identified with those in which its last vestiges have disappeared. They are the hatchments of the geological world, and indicate that life once existed where all other record of it has perished."*

Inattention to the chemistry of geology appears still to be felt, for we find Professor Hopkins, in his Inaugural Address at the Meeting of the British Association in Hull, thus expressing himself:

"The science of geology may be regarded as comprising two great divisions—the physical and the palæontological portions. The former may be subdivided into its chemical and dynamical branches. The chemical department has never made any great progress, though abounding in problems of first-rate interest; such, for instance, as the formation of coal; the segregation of mineral matter constituting mineral veins of all descriptions; the processes of the solidification and crystalization of rocks; of the production of their jointed and laminated structure; and many others. Interesting experiments are not altogether wanting on points such as these; but not sufficient to constitute, as far as I am aware, a positive foundation and decided progress in this branch of science. The problems, doubtless, involve great difficulties, both as regards the action of the chemical agencies themselves, and the varied conditions under which they may have acted. . . . . . We cannot too earnestly invite attention to this branch of geology on the part of those qualified to contend with its difficulties."†

* Old Red Sandstone, pp. 288—292. † Athenæum, p. 1068, September, 1853.

To complete the evidence on this particular branch of the argument, it is now only necessary to bring forward the promised proofs, that aluminous and arenaceous beds and shales intervene between the carboniferous part of the coal measures and the limestone beneath. For this purpose, besides referring to the incidental evidences which have already appeared in the quotations taken from the works of Sir Henry de la Beche, Dr. M'Culloch, and others, when establishing the position and character of the carboniferous limestone, I have to add the following extracts bearing more immediately on the present question:—

"With respect to the carboniferous group," says M. de la Beche, "the masses of the old red sandstone, carboniferous limestone, and coal measures are well separated from each other, though there may be small alternations at their contact."*

And again, quoting from Professor Sedgwick, he says—

"On the re-appearance of the carboniferous limestone at the base of the Yorkshire chain, we still find the same general analogies of structure—enormous masses of limestone form the lowest part, and the rich coal fields the highest part of the series; and we also find the millstone grit occupying an intermediate position. The millstone grit, however, becomes a very complex deposit, with several subordinate beds of coal; and is separated from the great inferior calcareous groups, not merely by the great shale and shale limestone, as in Derbyshire, but by a still more complex deposit, in some places not less than 1,000 feet thick, in which five groups of limestone strata, extraordinary for their perfect continuity and unvarying thickness, alternate with great masses of sandstone and shale, containing innumerable impressions of coal plants, and three or four thin seams of good coal, extensively worked for domestic use. . . . . . The alternating beds of sandstone and shale expand more and more as we advance towards the north, at the expence of all the carboniferous groups, which gradually thin off, and cease to produce any impress on the features of the country.†

"According to M. de Villeneuve, the coal measures and limestone strata alternate at their contact with each other between Liege and Chaude Fontaine. The limestones are metalliferous, bluish, and compact, and contain subordinate conglomerates of blue limestone. . . . . . The upper part of the limestone and sandstone contains aluminous shale, worked for profitable purposes.

"According to the same author, the coal measures, which are composed of the usual mixtures of sandstones, shales, and coal beds, present at the Montagne de St. Gilles, no less than 61 beds of the latter. . . . . The coal beds of Liege contain 83 beds of coal.‡

"M. Pusch describes the coal measures in Poland as extending from Hultschin to Krzeszowice. . . . . . A black marble employed in the arts supports the coal measures. M. Pusch considers this marble as equivalent to the carboniferous limestone of the English geologists, and observes that the calcareous conglomerates which accompany the coal sandstones and shales

* Manual of Geology, p. 431.

† Manual of Geology, pp. 431, 432, taken from Professor Sedgwick's Address to the Geological Society, 1831.

‡ Ibid, p. 436.

in the gorges of Miekina and Filipowice are referable to the same marble beds."*

And in conclusion from this author—

"After a thickness of seven or eight hundred feet of calcareous rock had been formed, another great change in the matter deposited was effected; not, however, so suddenly but that the arenaceous sediment which afterwards became so abundant, and the calcareous matter, were alternately produced for a comparatively limited period. An immense mass of sandstones, shales, and coal was then accumulated in beds, one above another, which, though very irregular with regard to the relative periods of deposit, are frequently persistent over considerable areas.

"By general consent the coal is considered as resulting from the distribution of a body of vegetable remains over areas of greater or less extent, upon a previously deposited surface of sand, argillaceous silt, or mud, but principally the latter, now compressed into shale."†

"The term shale," says Dr. M'Culloch, "includes all the secondary and tertiary argillaceous schists. . . . . . Its varieties are enumerated in the classification of rocks; and I need only remark here, that it is more or less indurated, and that its prevailing colours range from grey to black, but comprise also red and yellow hues of considerable variety. When highly ferruginous, it passes into argillaceous ironstone; and on becoming calcareous, into schistose marl, and into limestone.

"In this case in particular, or when interstratified with limestone, it is the frequent seat of fossil shells; while the argillaceous beds of such a series often contain a greater proportion of these than the calcareous rock. In the coal series it often contains bitumen, carbonaceous matter, or both; and, in the same circumstances, is the frequent repository of vegetable remains. . . .

"Some varieties of shale, like others of primary argillaceous schist, contain a decomposable pyrite; being therefore wrought for alum, under the name of aluminous slate.‡

"It must have been already understood," continues the same author, "from former observations, that the coal series is not anywhere found among the secondary strata, however steady its place may be where it exists; but that it occurs in distinct tracts often widely separated from each other. These are known, technically, by the term coal fields, and they vary in their characters in different places; not only in their extent and in their depth, but in the order of succession of the integrant rocky strata, in the numbers and relative proportions of these; and in the numbers, thickness, succession, and qualities of the beds of coal. . . . . . The strata which accompany the beds of coal, contributing to form what is here called the series, consist of sandstones, shales, limestones, and clays. . . . . . The characters of the sandstone vary, being in some places a conglomerate, but more frequently fine, when it is sometimes compact, pure, white, at others micaceous, or argillaceous, or ferruginous and tender, occasionally also containing pyrites, and often blackened by carbonaceous matter, or else including distinct fragments of charcoal. . . . . .

"The shales vary much in aspect and hardness, passing at length into

* Manual of Geology, p. 437.

† Ibid, p. 441. *Shale*, according to Mr. Lyell, is "a provincial term adopted in geological science to express an indurated slaty clay." Vol. iii. glossary.

‡ Geology, by Dr. M'Culloch, vol. ii. pp. 248, 249.

clays equally various, and sometimes containing bitumen, carbonaceous matter, and vegetable fragments. In this class imbedded nodules, or distinct strata of argillaceous ironstone often occur, and in conspicuous quantities, forming the principal supply of ore for the iron foundries."*

"The most remarkable accumulations of coal," says Professor Buckland, "in England are in the Wolverhampton and Dudley coalfield, where there is a bed of coal ten yards in thickness. The Scotch coalfield, near Paisley, presents ten beds whose united thickness is one hundred feet. And the South Welsh coal basin contains, near Pontypool, twenty-three beds of coal, amounting together to ninety-three feet.

"In many coal-fields the occurrence of rich beds of iron ore in the strata of slaty clay that alternate with the beds of coal, has rendered the adjacent districts remarkable as the site of most important iron foundries; and these localities, as we have before stated, usually present a further practical advantage, in having beneath the coal and iron ore a substratum of limestone that supplies the third material required as a flux to reduce this ore to a metallic state."†

Concurring testimony, to the same effect, is borne by Messrs. Lindley and Hutton, although they had occasion to advert to the circumstances only incidentally, when describing the fossil flora of the coal formations:—

"The beds usually denominated the coal measures" (say they, in part 1st of vol. ii. pp. vi. and vii.), "being the higher part of the carboniferous formation, repose upon, and are conformable to, the inferior members of the series.

"They consist of irregularly alternating beds of sandstone, shale, or argillaceous schist and coal, whose aggregate thickness (in Northumberland and Durham), may be estimated at about three hundred fathoms. This may not probably be correct, but is near enough to the truth for our purpose."

The following evidence, given by MM. Prestwich and Murchison before the Geological Society, is interestingly corroborative of these alternations in the coalfields.

"Mr. Prestwich," say the editors of the Literary Gazette, "commences his account of the formations by describing the lower silurian rocks. These deposits constitute a narrow belt of highly inclined strata around the Wrekin and Arcol hills, and are composed in the lower part of a friable, coarsely-grained quartoze grit, and in the upper part of micaceous flags. The Caradoc sandstones are next described; and afterwards the Wenlock shale and limestone, the Ludlow rocks, the old red sandstone, and the carboniferous limestone; and, finally, the coal measures. These are formed of the usual alternations of shale, sandstone, and coal; and in those portions of the district where they are most fully developed, have been ascertained to consist of 135 beds, making a total thickness of about 250 yards. The colour of the first 70 or 80 beds, commencing at the top, is light grey, yellow, or red; that of the next twenty is very dark, or nearly black; and that of the underlying strata is light. These distinctions prevail generally, but not universally. In the upper part of the series clays and soft calcareous sand-

* Geology, by Dr. M'Culloch, vol. ii. pp. 301—303.

† Bridgewater Treatise, vol. ii. p. 529.

stone predominate; in the middle argillaceous sandstones or clays; and in the lower hard fine-grained sandstones, occasionally micaceous. The beds of coal in the upper division of the series are widely separated, and extremely irregular; but in the lower they are thick, nearer together, and are persistent throughout the whole field. At some of the pits the beds vary greatly in number and thickness, in consequence of the thinning out of some, and the interpolation of others; and the memoir contains a valuable series of sectional lists obtained from the ground bailiffs.

"Next in importance to the beds of coal are the layers of argillaceous carbonate of iron. This valuable ore generally occurs in flattened nodules constituting regular seams, which are distinguished by the names of penny-stone, the chance-stone, the ball-stone, the ragged-robbins, &c. &c. Some of these layers extend throughout the field, but others are of local occurrence; and the aggregate number in a pit varies from two to seven. They are generally embedded in shale, but occasionally in sandstone. In some parts of the district, and situate near to the top of the series, is a bed of freshwater limestone. The petroleum, or tar spring, for which Colebrook Dale has been so long celebrated, issues from a thick bed of sandstone in the upper part of the coal measures. . . . . Titanium has been produced in considerable abundance in the iron furnaces.*

No further evidences, it is presumed, need be given to prove the existence of extensive stratified formations, consisting of clay, sandstone, and shale, associated with the carboniferous limestone, and generally underlying the coal measures.

The calcareous deposits, it has been shown, owe their origin, in a great degree, to the exuviæ of innumerable testaceous and conchiferous mollusca and zoophyta, and to the chemical decomposition occasioned by their death, whereby they promoted the deposition, from the surrounding water, of the components of those aluminous, arenaceous, and shaly strata which are intermixed with, and found covering, their fossilized remains; electrical influences having been also employed as a slow but certain and universal agent to co-operate with these other causes, and to complete the deposits in question.

It is necessary, at this juncture, to allude again to the irresistible inclination which water, impregnated with various elements, has to assume a state of chemical equilibrium whenever the disturbing causes have ceased to exercise their influence over the mass; or, in other words, whenever the chemical affinities of the several ingredients become stronger than the disturbing influence.† Now, there is scarcely any fact in geology better authenticated than that, during the entire course of the older formations, there was a succession of plants and of inferior animal life differing from the present generations in proportion as their remains are distant from the surface.‡

This, therefore, having been the case, it is natural to conclude, that each race, as it approached extinction, would exercise a dimi-

* Literary Gazette, 16th April, 1836, pp. 248, 249.

† 69th Theorem and proofs. ‡ 16th and 133rd Theorems, and their proofs.

nished influence on the surrounding medium, until at length it reached a point when it would be altogether nihil.

I am persuaded that the subject of the preceding observations has not been sufficiently dwelt upon by others, nor has it attracted that attention which it ought. For, if properly considered, it may assist, in part, to clear up the mystery which hitherto has enveloped the operations of those long by-gone times. The fact of there having been successive races of inferior animal life throughout the stratiferous period of the ancient ocean, combined with the assurance, acquired by the registered accumulations of their fossilized remains, "that there is not one solitary example on record of a race or species which had become extinct ever having been thereafter re-created,"* when contrasted with the *permanency* of the recent allied tribes of inferior animal life in our *present seas*, seem to afford a clear glimpse of the operations which were then going on, and the changes which were taking place underneath the dark, and otherwise incomprehensible primitive water.

For, although the more rigorous proof of analysis at any of these periods of important change is now out of the question, yet these stereotyped vestiges denote the mutations of the scene in a way scarcely less certain. The ever-changing, mingling fluid has come down to us in its purified state, bringing no evidences in itself of what it once was, but it has clearly recorded the progressive stages through which it has passed by the indelible legends written and left behind it in stony concretions, the former habitations of its living associates, as it passed onward and onwards to its present limpid condition; while those endurable records, if properly studied and applied, may be found of essential benefit in guiding us through the maze which lies before us. Striking contrasts, by arousing the attention, sometimes become useful in such mental exercises; and none can be more so, perhaps, than that which is afforded by the *static* condition of the water of the actual ocean and the permanency and persistency of its inhabitants, when put into juxta-position with the *mutation*, so well authenticated, which took place in the living forms of ancient times and a progressively purifying medium. A continuous *change* in the character of marine animal life, with the *static* condition of our "seas," is not more imaginable than is a *static* condition of the primitive fluid with the *mutability* of its living inhabitants! Judging by the laws which govern materialism, neither the one combination nor the other can, consistently, be imagined.

But in addition to the legends which the ancient ocean has bequeathed to us by means of the fossilized remains of its inhabitants, we are happily furnished with a series of threads of the slenderest and most even description, which, throughout the whole of this shoreless and atmosphereless water, have passed up with unbroken

* Ancient World, Ansted, p. 56.

continuity from the earliest dawn of animal life to the latest geological formation; I allude to the calcareous formations. *Lime*, wherever it has been taken for analysis, has been found to be identically the same.* And this holds good whether that which is examined be derived from the nethermost series of rocks, or from the coral islands of the present seas. Now, without stopping to enquire whether *calcium* itself be peculiarly an animal *secretion*, but proceeding on the general admission that *lime* is an animal *product*, and presuming that its production was one of the designs of the Creator during the stratiferous period of the primitive ocean, and even to the present day, and taking into consideration that a substance which, from its first appearance on earth to the last particle yet formed in the sunny seas of the enter-tropical regions, was destined to be invariable, although produced by successive and distinct races of marine animals, there is no other alternative but to conclude, that to continue the unvarying nature of the animal product, *Lime*, it became requisite to adapt the form and construction, and consequently the physiological powers of the elaborators, to the menstruum from which they extracted it, as this changed from stage to stage. Analysis testifies that the *product* has ever been the same. We are as equally well assured that the fabricators have not always been the same, but on successive occasions they have been *changed*; a combination of these two terms can leave no doubt upon the mind, that the menstruum, from which the latter derived the elements of the former, was likewise undergoing a corresponding alteration.

That the deposition here referred to (which was so essential), should, however, be continued, new races of animals adapted to the altered medium, and capable of deriving sustenance from it, would no doubt be willed successively into existence; and the fate which awaited their predecessors, would, in time, also overtake them. Consequently, what has been said of any one generation of inferior animal life may, with equal justice, be applied to all the others, while it likewise points out that the primitive water would, in all probability, eventually assume such a condition as that animal secretion, alone, might not be suited to drain it of those peculiar elements, which the ulterior plans of the Creator required that it should part with; and, therefore, it might have been conducive to employ the influence of vegetable vitality to assist in carrying on the process of purifying the ocean, and cause to be deposited, at its base, masses of carboniferous material which vegetable secretion, alone, could accomplish.

Geology seems to corroborate, very fully, this view of the case; for we are shown, as the result of its researches, that not only were there new races of shelly animals brought into existence about that period, but plants likewise. For this very important modification

* 16th Theorem, section F.

in the plans of the Creator, due preparation seems to have been made. One of the tendencies of the chemical composition and decomposition which had been going on in the primeval water was to impregnate the menstruum with the element of carbon, the main ingredient in the construction of woody fibre. And this, then, must have been the epoch when it pleased the Creator to bring to perfection the submarine vegetation whose accumulated remains were providentially destined to furnish, in after ages, to an entirely distinct race of beings, that which, in time, would be as essential for *their* use and comfort as what was held in chemical suspension had been for the growth of those plants which elaborated the carboniferous portion of the coal measures.

Considering that we can, with so much certainty, trace back the formation of the great coal deposits to the earlier ages of the creation, and thereby are constrained to acknowledge the goodness and manifest design of Providence in heaping up those vast subterraneous stores which contribute alike to the power and to the comfort of man, we assuredly ought not to doubt, for one moment, of its having been the same beneficent hand which, with equal priority, provided for the requirements of those inferior beings which he saw fit in his goodness, and found necessary by his wisdom, to will into existence, when *their* peculiar agency was required to work out his sovereign pleasure during *their* day and generation. I am thoroughly persuaded myself, and would most willingly persuade others, that the confidence arising from experience in our day ought to be applied by analogy, to the case of all those inferior races of plants and animals, whose existence has been made known to us only by their fossilized remains.

The manner in which they were collocated on the earth's submarine surface shows, also, that everything was done with consummate wisdom; for it is in perfect accordance with the known habits of plants and fixed animals (without at present taking into account other apulmonic inhabitants of the water), to increase by radiating from centres or foci.* Placed, as they no doubt were, at appointed and proportional distances, they would at length, by gradually extending their respective areas, intermingle along their borders of demarcation, and fulfil the object of their original collocation towards the ultimate end in view, namely, that of producing a variegated whole, fitly jointed together, and well adapted for preparing strata, capable of being applied to what was designed, with a view to the great revolution which was to take place when the earth should be caused to rotate around its axis. Thus every successive stage in the work of creation affords convincing evidence of the most perfect wisdom and beneficent foresight having been exercised in preparing for it.

What has preceded, distinctly points out the adaptation of the

* Principles of Geology, by Mr. Lyell, vol. ii. p. 131, et sequitur.

means to the end, whose accomplishment has been attested by the researches which geologists have made into the external crust of the earth; in some localities there having been discovered the remains of wide and extended colonies of shell-fish alternating with those of broad patches of vegetation; and in other parts, symptoms of both having partially intermingled.

The idea of successive creations of animated beings previous to the general one, narrated, in Genesis, by the inspired historian, may appear to some to be heterodox. I do not insist on any one agreeing with me in those points of belief; yet it is due to all to explain, that being most firmly convinced that everything which is, was created by God, I can recognise no just grounds, considering I believe in the later or ultimate acts of his creative energy, to withhold my belief as regards those instances of greater antiquity. Besides, if the successive tribes of plants and testaceous animals, so often alluded to, were *not* created in succession during the period of non-rotation, *they were not formed at all*, for no *direct* mention is made of them in the narrative given in Genesis: their *previous* creation being deducible only by inferences arising out of the differential mode of reasoning which has been applied to that part of Scripture. But as, in confirmation thereof, geology reveals their existence, and sound reasoning leads us to imply their uses, no motive remains for withholding assent to the only deduction which can, legitimately, be drawn from the facts of the question, and from the unlimited powers of the Creator, namely, *that there were several successive creations of both animals and plants, during a long but indefinite period in the earlier geological history of the earth.*

In addition to the direct proofs in favour of the inference which has just been come to on this point, the consideration, that layer after layer of inert matter was accumulated upon each other until they attained an immense aggregate thickness, precludes us from conceiving, with propriety, that any *one creation* of animals* or plants could have surmounted these accumulations, and have survived throughout their whole duration; it being quite at variance with sound analogy to suppose that the spawn of testacea or zoophyta, or the sporules of acotyledonous plants could have done this, even could these animals and plants have derived sustenance from the surrounding medium which was itself continually changing by the effects of their own drainage, and by those of chemical affinity. On the contrary, they must each eventually have been, as they really were, buried under the effects of these joint causes; and, finally, in consequence of the change produced on the elements of the primeval ocean, a corresponding change was essentially neces-

* Even the polypiferous creatures which have been most persistent throughout the whole geological era, seem, from their productions of earlier times, to have been distinct in some respects from those which now inhabit the ocean.—Ancient World, page 32.

sary in the adaptation of its animal and vegetable inhabitants, in order that the process of purification should be continued.

When a general view is taken of the works of the Creator, and when, with more speciality, the attention is restricted to the construction of the complex and finished piece of mechanism of the human frame, and we behold its numerous muscles, each wrapped in its own ponobrotic envelope, meeting, and even overlapping, in order that they should, in their several departments, perform the work assigned them, and conjointly constituting an harmonious whole, well adapted for the end intended, we should have no hesitation in supposing that similar forethought and design were applied to the collocation of the strata, and to the formation of the great body of the earth. It is true, the objects are incomparably dissimilar in size; yet the gigantic parts of the earth will be found to be in as perfect proportion as those of the human frame; and were we more narrowly to trace the special design of each, we would, no doubt, discover equal wisdom and intention pervading them both. It would be found that as the ponobrotic coverings are useful to the muscles in protecting them from the effects of friction, *inter se*, so the *limestone* and *shaly formations* rendered a similar service to the coal measures, when the first rotation of the earth caused the developlopment of so much heat as would, without these impervious barriers, have fused and rendered those immense store depôts of fuel utterly unserviceable. And we shall, at last, be convinced that the same Almighty hand—which fashioned the earthy mould of our first progenitor into bones, muscles, ligaments, and manifold winding conduits, and filled them with fluids ere yet these last had circulated or beat a single pulsation—did, with the same consummate wisdom and forethought, lay down every distinct bed of calcareous, carboniferous, or aluminous strata, in ready preparation for that eventful moment, seen by himself, from all eternity, when, by the formation of light, the dark, motionless orb was caused to start into its description of life, and to rotate in the gladdening rays of a sun, which was to be illumined almost immediately thereafter, as the inexhaustible reservoir of its light and heat, and the teller of its signs, its seasons, days, and years.

SECTION III.

DEPOSITION OF THE STRATA DURING THE NON-ROTATORY PERIOD.

CHAPTER XII.

Prefatory observations respecting the universal warmth which prevailed in the water of the non-rotating sphere. Chemical action the principal secondary agency employed in producing that result. Effects of animal and vegetable vitality again alluded to. The consequences arising also from the death and decomposition of animals and plants particularly investigated with reference to the purification of the ancient ocean; more especially the effects of ammoniacal exhalations arising from the putrefaction of animal remains. Geological data, and actual results adduced in corroboration. The "blending" and the "thinning out" of the strata attempted to be accounted for by the Dynamical Theory. And, in conclusion, an endeavour to explain, according to the same principles, by what means the primitive ocean changed its character from turbid, fresh water, to the saline and pellucid seas of the present period.

Allusion has already been made to the ample provision for the nourishment of the vegetable kingdom of this early period, by the suffusion into the water of carbonic acid arising from the decomposition of animal matter; and reverting now to the warmth, so often before alluded to, which prevailed throughout the water during the formation of the great coal measures, I shall endeavour to trace the source of this increased temperature. It would, assuredly, be an unwarrantable use of the reasoning faculties conferred on finite beings, to attempt to raise any veil which has purposely been cast over his works by the common Creator, or to dogmatise on points of such entity as whether *economy in time* is an object of importance to a Being who inhabits eternity. Yet the investigation of his other works reveals a principle of the most rigid economy running through the whole—in the *weighing* of every atom, and in the *measuring* of every drop of fluid; and we are, therefore, authorized to conclude that the same principle has been exercised in *duration* also. It would appear that, while economy in time was studied in the plan of the Creation, the most inferior creatures were carefully nurtured, and every thing, consistent with their several natures, was done to enable them to assume the fullest expansion of which they were respectively susceptible. Warmth very essentially contributed to effect this, and warmth was conferred upon them. Its existence, *by inferences drawn from the gigantic relative size of the*

organic remains, has already been demonstrated in a previous chapter. I shall, therefore, in this, proceed to trace the secondary agency employed in its development. To do this let us, first of all, refer to the *forty-ninth* Theorem, viz.:—"*That it may be assumed, as a general principle, that chemical combination is one of the numerous causes by which heat may be developed or absorbed; while caloric, or heat, is itself the most general agent employed in all chemical operations;*" and, in continuation, peruse briefly some of the authorities which support this conclusion.

"One of the chief agents in chemistry," says Sir John Herschell, "on whose proper application and management the success of a great number of its enquiries depends, and many of whose most important laws are disclosed to us by phenomena of a chemical nature, is *heat*.

"The most obvious sources of heat are the sun, fire, animal life, fermentations and violent chemical actions of all kinds, friction, percussion, lightning, or the electric discharge, in whatever manner produced, the sudden condensation of air, and others so numerous and so varied as to show the extensive and important part it has to perform in the economy of nature. The discoveries of chemists, however, have referred most of these to the general head of chemical combination. Thus, fire or the combustion of inflammable bodies, is nothing more than a violent chemical action attending the combination of their ingredients with the oxygen of the air. Animal heat is, in like manner, referable to a process bearing no remote analogy to a slow combustion, by which a portion of *carbon*, an inflammable principle existing in the blood, is united with the oxygen of the air in respiration, and thus carried off from the system; fermentation is nothing more than a decomposition of chemical elements loosely united, and their re-union in a more permanent state of combination, &c."*

"It may be taken, says a writer in the Cabinet Cyclopædia, "as a general principle, that chemical combination is one of the numerous causes by which heat may be developed or absorbed. Every part of chemical science abounds in facts illustrative of this principle."†

"Combustion," writes Dr. Ure, "is the disengagement of heat and light which accompanies chemical combination. . . . . . Whenever the chemical forces which determine either composition or decomposition are energetically exercised, the phenomena of combustion or incandescence, with a change of properties, is displayed. The distinction between supporters of combustion and combustibles, on which some late systems are arranged, is frivolous and partial. For, in both cases, the heat and light depend on the same cause, and merely indicate the energy and rapidity with which reciprocal attractions are exerted. Thus, sulphuretted hydrogen is a combustible with oxygen and chlorine; a supporter with potassium, &c. &c.

"From the preceding facts it is evident that no peculiar substance or form of matter is necessary for producing the effect (evolution of heat); but it is a *general* result of the actions of any substances possessed of strong chemical attractions or different electrical relations, and that it takes place in all cases in which an intense and violent motion can be conceived to be communicated to the corpuscles of bodies.

* Natural Philosophy, Cab. Cyc. pp. 310—313.
† Dr. Lardner on Heat, Cab. Cyc. p. 354.

"Finally, we may establish it as an axiom, *that combustion is not the great phenomenon of chemical nature, but an adventitious accidental accessory to chemical combination or decomposition; that is, to the internal motions of the particular bodies, tending to arrange them in a new chemical constitution.*"*

Before concluding this branch of evidence, it may not, perhaps, be superfluous to notice particularly certain substances which evolve considerable heat on combining with others. The acids, in general, on combining with water evolve heat.† Azote and phosphorus combine at common temperatures, and produce heat without light.‡ Iodine also produces combustion in uniting with azote and other substances by the intensity of their mutual action. And as this peculiarly energetic substance has been discovered in most of the fuci, and several of the other algæ,§ there can be no doubt of its presence, and, consequently, of its effects. That the circulation of voltaic electricity is accompanied by a continued development of heat, lasting as long as the circuit is complete.‖ And, lastly, "That water has a greater capacity for caloric than an equal bulk of any solid substance known."¶

After what has been so recently said, it may scarcely be requisite to reiterate, that the warmth which existed during the incipient stage of creation, and with which we have just been occupied, could not have been occasioned by the sun's rays; for that orb was not yet illumined; neither was it the effect of radiation from masses of heated mineral matter, for the hills and continental ranges had not been moved from their original horizontal position, had undergone no friction, consequently were not imbued with any superabundant heat, which, by requiring to part with, they would have communicated to the surrounding media; and therefore we are shut up to the necessity of considering, that the secondary agency of the heat or warmth in question *was electrical currents and chemical combination and decomposition.* But "heat occasioned by chemical action is derived," as has just been shown, "from motion amongst the corpuscles of elementary bodies, while its rate is determined by the rate of that intermotion." And as, on the other hand, we are equally well assured "that matter can neither produce in itself spontaneous action, either from a state of rest to that of motion, or diminish any motion it may have received from an external cause, or change its direction;" it is, ultimately, obliged to be confessed, that whatever may have been the nature of the intermediate agency, or the instruments employed to occasion the intermolecular motion engendering that warmth, which all geologists agree in considering did exist throughout the primitive ocean, *its ultimate cause was not, could not have been material.* We must look to what is beyond matter, to a higher source, and to a distinct set of evidences—evi-

* Chemical Dictionary, pp. 353, 354, 368. † Ure, p. 5.
‡ Ure, p. 540. § Ibid, p. 537. ‖ Connexion of the Sciences, pp. 306—312.
¶ Hutchison's Essay on Unexplained Phenomena, pp. 25, 26.

dences which, for our assurance and satisfaction, are plainly and unequivocally set before us.

As the present part of the argument, however, admits of being conducted with reference more directly to the material and secondary agency employed, I shall, therefore, proceed by that line of approach.

The warmth in question having proximately been engendered by chemical and electrical action, it follows, that its maximum would be wherever these were in greatest activity. This was at the bottom of the ocean, throughout its whole extent; where myriads on myriads of animals and plants were incessantly at work imbibing the materials chemically suffused in the water, and elaborating them into the substances of which their bodies and their coverings were composed. *There* also the lower stratum of water, by being despoiled of its earthy associates, and impregnated with ammoniacal gases, by exhalations from decomposing animal matter, would, in addition to the extent of volume, acquire a reduced specific gravity, and be made to ascend, to give place to colder and less pure portions, to be in turn freed from their earthy load, and expanded by warmth; and thus a constant and equalizing current would be kept up between the lower and the upper surfaces of the great mass of water constituting the primeval ocean. The peculiar adaptation of this alternation, which caused the earth-charged portion to descend and deposit its load within reach of those apulmonic beings which required the supply, and would, otherwise, have been deprived of it; and, on the other hand, which raised whatever of the ammoniacally impregnated portion escaped recombination with suffused bases to the surface, for purposes of future usefulness, showed forth the same provident forethought so strongly illustrative of the whole proceedings of the Creator; and fills the mind with admiration. While it should not be forgotten that the material crust of the Earth, whose construction was partly accomplished by these, though it could not thereby have acquired a *heat* approaching in any degree to fusion, would become the regulating reservoir of a considerable residue of that warmth which was thus constantly evolving itself along the whole extent of its submarine surface; and whose accumulation in the water was much assisted by the great capacity of this for caloric and by its atmosphereless condition; the whole having been, as it were, conducted in vacuum.

The mind being sufficiently prepared, by the review which has been laid before it of the adaptation of the material part of the Creation during the anti-rotatory period, to the species of animal and vegetable life then willed by the Omnipotent into existence, it becomes requisite to enquire, next, what would be the probable results, according to natural causes, of their growth and propagation, and, afterwards, of their decay and death. There is little to be added to what has already been brought forward, respecting the agency of the

animal kingdom in the composition of the solid strata. During their lifetime they secreted calcareous coverings, whose remains have contributed very considerably to the formation of the limestone series. After death the elementary components of their fleshy parts appear to have entered into a new series of binary and ternary compounds, which—in seeking the level their reduced specific gravity induced them to do—disturbed the chemical equilibrium of the water through which they ascended, and assisted to cause the precipitation of aluminous, calcareous, arenaceous, and other deposits, which partly intermingled with, and partly covered, their endurable remains.

The services which were performed by living plants in secreting and accumulating carbonaceous matter in their own gigantic forms, and by instilling certain deposits into the strata by exudation from their roots, have been fully explained in the chapters which were dedicated to the primeval vegetable kingdom. Consequently, at present, I have merely to enquire into the effects which were likely to have occurred by the decomposition of vegetable substances—in as far as they differ from those produced by animal decomposition —when introduced, by exhalation, into the surrounding fluid; the disturbance they were capable of occasioning in its chemical equilibrium; and the effect which animal and vegetable exhalations would have on each other when intermingled by the luni-solar current; and the new compounds they would form, and precipitates which they would throw down.

To accomplish the first of these objects, I shall commence by recapitulating the *hundred and twenty-eighth* Theorem, "*That when the principle of life has departed from vegetable substances exposed to the atmosphere, they begin spontaneously to decompose, and their remains, entering into new combinations, form carbonic acid, water, carbonic oxide, and carburetted hydrogen; these modifications continuing until nothing remains but the saline, earthy, and metallic substances originally contained in the vegetable matter. But when the exclusion of the atmosphere, and considerable pressure take place, the former circumstance removing the agency of oxygen, and the latter preventing the formation of elastic products, the decomposition does not proceed beyond the accumulation of a carbonaceous residium; from which it is probable have been derived the several varieties of bitumen and coal;*" and as these truths may exercise considerable influence over the subsequent argument, I shall strengthen their impression by a few concise and apposite quotations:—

"All vegetables," says Mr. Reid, "when the principle of life has departed from them, begin spontaneously to be decomposed. Their elements have a tendency to separate from each other, and form new compounds very different from those which compose the living plant. These are carbonic acid, water, carbonic oxide, and carburetted hydrogen. The two former are the chief results of the decomposition, the two latter are formed more sparingly, and principally when there is not a free supply of oxygen. . . . . In vegeta-

bles which decay under water, carburetted hydrogen is abundantly formed; hence arises the gas which is found so plentifully in summer in stagnate waters, which contain quantities of putrefying vegetables."*

"To this" (vegetable decomposition), says Dr. Murray, "the name of putrefactive fermentation has been given. . . . . . . The elastic products disengaged are compounds of carbon, and hydrogen, and carbonic acid. . . . . . . There is no sensible production of ammonia, or of gases containing sulphur and phosphorus, the evolution of which more particularly characterises animal putrefaction, a difference arising from the absence of these elements and of nitrogen in the composition of vegetables. . . . . . .

"Carbon being, in general, the base of vegetable matter, it frequently remains, forming an inert residium after the decomposition has proceeded to a certain extent, constituting what is termed vegetable mould. This, when the air is excluded, is scarcely liable to further change, there being no other principles to act on it with sufficient force.

"It appears that often from the operation of circumstances, probably the exclusion of the atmosphere, and the presence of pressure, the decomposition does not proceed beyond the accumulation of this carbonaceous residium; the former circumstance removing the agency of oxygen, the latter preventing the formation of elastic products; and from the process conducted under these circumstances, and from vegetable matter being originally composed chiefly of carbon, as wood, have probably principally originated the different varieties of bitumen and coal, the origin of which, from the vegetable kingdom, can be so often traced."†

"When vegetables putrefy," says Mr. Donovan, "the changes are not so complex as in the case of animals, because the elements concerned are fewer.

"The oxygen combines with hydrogen; another portion of hydrogen combines with carbon. The chief part of the carbon remains as such, unless free access of air be admitted, which then slowly combines with it.

"During the putrefaction of animal and vegetable matter, much heat is produced; and if the mass be considerable, the heat continues a long time."‡

It appears from these authorities that, with the exception of carbonic oxide, the gaseous products arising from the decomposition of vegetable substances under water, are, in some respects, similar to those which proceed from the decomposition of animal matter; that carburetted hydrogen is the compound gas most abundantly given out; but, that ammoniacal gases never originate from the decomposition of *vegetable* substances under any circumstances, whilst the exclusion of air causes the material residium to consist almost entirely of carbonaceous matter or vegetable mould.

Taking into account that the luni-solar current, which flowed in the primitive ocean, and has been so fully described in a previous part of this work, would have the effect of gradually bringing strata of water, charged with gaseous exhalations arising from animal de-

* Chemistry, by Hugo Reid, pp. 178, 179.
† Chemistry, vol. ii. pp. 570, 571.
‡ Chemistry, in Cab. Cyc. p. 343.

composition, over parts of the earth's submarine surface producing plants, and *vice versa*, of carrying the exhalations from decaying vegetable substances over regions inhabited by fixed animals, it remains to be ascertained, what would, in such circumstances, be the probable result when the decomposition of animal substances, by their exhalations ascending into the fluid mass which held the various materials in solution, threw down deposits on the plants.

The products of these decompositions were, as I have repeatedly observed, all gaseous; some of them of considerable specific gravity. Water possesses the capability of absorbing several times its own bulk of many of those which were then present. This would render the portions of water, which were impregnated with those of greater specific gravity, heavier than others, and cause them to descend. But on the other hand, those strata of water which were combined with ammoniacal gas being of lighter specific gravity, together with the increased temperature of the lower aqueous strata in contact with the bottom—where chemical changes were in more active operation—would be caused thereby to ascend, and, by giving place to heavier strata, would produce a continued alternation of currents.* Had the fluid mass, in which those relative movements were taking place, been itself stationary with respect to the solid part of the earth, the currents, whether ascending or descending, would have been in directions perpendicular to the surface; the gaseous elements of reduced specific gravity would have risen directly from the spot of their exhalation. The deposits would have descended from the precise points of their liberation; but when it is taken into account, that the luni-solar attraction, by operating upon the water of the ocean, kept it in a continued flow from east to west, these perpendicular currents would not take place. But by the rule for the composition of forces the direction of the ascending and descending particles is to be determined; it would be a diagonal compounded of the two motions.† In this direction, then, the effects of the ascending exhalations would be in operation; while the continued westerly flow of the whole moving mass, by diverting the deposits also from a perpendicular, would co-operate with the other to place them much to the westward of their efficient cause. This

			SPECIFIC GRAVITY.
* Of ammonia water can absorb	670	times its own bulk	0.59027
Muriatic acid	500	ibid	1.28472
Sulphurous acid	33	ibid	2.2222
Chlorine	2	ibid	2.5000
Carbonic acid		ibid	1.04166
Nitrous oxide		ibid	1.18050
Sulphuretted hydrogen . . .		ibid	1.5277
Olefiant gas, or carburetted hydrogen, 1-8th its own bulk			0.5555
Oxygen, and nitric oxide, 1-27th its own bulk			1.5277
Nitrogen, hydrogen, and carbonic oxide, 1-64th its own bulk			1.04166 / 0.9722

(Chemistry, by Hugo Reid, p. 108, and Dr. Thompson, p. 734).

† Mechanics, in Cab. Cyc. pp. 49, 50.

divergence, when all the exhalations were supposed to have been of animal origin, was of so little consequence that no notice was then taken of it; but this is now no longer the case, for it becomes very important in the present stage of the argument, inasmuch as it can be applied to prove that, although the extensive patches of animal and vegetable existences might have been perfectly separate from one another, yet the effects produced by their extinction would, in consequence of the flow of water carrying the compounds formed by their decomposition to great distances, be attended by one universal result over the whole space; and a general deposition, it is presumed, would take place of silex, alumina, lime, magnesia, potash, soda, and oxides of iron and manganese, which, uniting with those already formed in the several localities, would—according to that which had already been deposited there—assume the respective forms of clay, shale, or sandstone, varied in conformity to the original nature of the exuviæ on which the precipitates fell.

When, by the exhaustion of the exhalations, the disturbing power began to diminish, the aluminous and arenaceous strata—which entombed the calcareous exuviæ of the animals, and the carbonaceous remains of the vegetables—would have attained their maximum thickness; and we have only to carry forward our conceptions a little further, to arrive at a point when, like that to which I formerly alluded, the power possessed by those gaseous exhalations to disturb the general equilibrium, would be proportional to the races which survived the deposition. At this point new creations of vegetable and animal existences, each with an organization suited to the purified state of the surrounding element, would be essential for effecting a further disturbance of the equilibrium, and an acceleration of the deposits which would result from its derangement. Thus we have an approximative explanation of the probable cause which motived another change in part of the organic life, both vegetable and animal, which encrusted the bottom of the original ocean, derived from what has been made known by the nature of the fossil remains brought to light by the researches of geologists.

These new creations would, in the course of time, be productive of effects analogous to those which have been so minutely described, therefore a detailed repetition will be unnecessary. By draining the ocean during *their* lifetime of part of the remaining elementary materials held by it in solution, which were as essential for *their* peculiar secretions as those which were drained before had been for their predecessors, they would thereby gradually unfit it for continuing to administer to the wants of their own race; while they rendered it more capable of nourishing others of dissimilar habits destined to succeed them, and also brought the whole mass one step further in progression towards its present limpidness and purity. By the exhalations arising from their decay and decomposition, they would gradually, though slowly, entomb their own re-

mains in a mass of stony matter, whose decomposition would also contribute to accelerate the desired change or preparedness of the water; while the combined effect of those several causes would be to add layer after layer of solid, stratified material to the envelope which it pleased the Creator to form around the earth, in order that it might afterwards fulfil the ulterior design he had in view, when the whole sphere, thus curiously and elaborately encircled, coat after coat, with rocky strata fitly joined together, should be caused to revolve around its axis by the introduction of the primary light and its division from the darkness.

Thus far I have endeavoured to explain, in a cursory manner, how the deposition and formation of the secondary strata was effected. Difficult as the subject is, from the absence of all direct evidence, and the necessity, therefore, of leaning so implicitly on results, and of tracing them backwards through their progress of accomplishment to their ultimate visible or material causes, I have made an attempt, though merely to indicate what the process of creation may have been, in the hope that others, better qualified, may resume and continue the undertaking until they carry it to perfection. Meanwhile it seems conceivable, that in some such progressive manner and under the few but comprehensive laws which *then* governed materialism, the depositions and encrustations constituting the secondary strata took place. And, likewise, that science possesses stores of accumulated knowledge sufficient to unravel, with perfect and convincing precision, as much of those operations, during that incipient age of the earth as shall be requisite, in conjunction with the sacred narrative, thoroughly to establish our faith in the announcements given with respect to what no mortal eye was privileged to behold.

Should what I have endeavoured to accomplish, amidst the discouragement arising from the conviction of incompetency, be the means of pointing the way to a more satisfactory explanation of the manner in which the older strata were deposited from the ocean, which held their elements in mechanical suspension and in chemical solution, it may also explain, to a certain extent, that which is mentioned in the *fifteenth* Theorem, namely, the indication shown by many of the stratiform masses, to *blend* into one another in mineralogical character, when examined in the order of superposition; causes sufficient having been adduced during the discussion to account for the *blending* of one rock into another. But there is still another peculiarity mentioned in the same Theorem, which it is necessary to notice, namely the "thinning out," or mineralogical *transition* of the strata, when traced continuously to any distance in a horizontal direction.

Let it first be shown, from undoubted authority, that such is really the case; and, afterwards, I shall endeavour to account for it by an application of the principles sought to be established:—

"If you enquire," says Mr. Lyell, "into the true composition of any

stratum, or set of strata, and endeavour to pursue these continuously through a country, it is often found that the character of the mass changes gradually, and becomes at length so different, that we should never have suspected its identity if we had not been enabled to trace its passage from one form to another. . . . . . .

"But, notwithstanding the variations before alluded to in the composition of one continuous set of strata, many rocks retain the same homogeneous structure and composition throughout considerable areas, and, frequently, after a change of mineral character, preserve their new peculiarities throughout another tract of great extent. Thus, for example, we may trace a limestone for one hundred miles, and then observe that it becomes arenaceous, until it finally passes into sand or sandstone. We may then follow the last-mentioned formation throughout another district as extensive as that occupied by the limestone first examined."*

"The most perfect form of a stratum," Dr. M'Culloch states, "is that in which the two planes are accurately parallel, but it is the most rare. They are more commonly inclined in different ways; so that a bed terminates at length, in one or more directions, or in all, by a thin edge; while it may also present surfaces so frequently and unequally inclined or undulated, as to be of various degrees of thickness throughout."†

"Professor Sedgwick has shown," says M. de la Beche, "that still further north in England the great line of distinction between the carboniferous limestone and the coal measures are broken up, and that the one rock is lost in the other. . . . . . . The alternating beds of sandstone and shale expand more and more as we advance towards the north, at the expense of all the calcareous groups which gradually thin off, and cease to produce any impress on the features of the country. . . . . .

"It may be questioned, at least in parts of Scotland, how far the lines of distinction can be drawn between the upper part of the coal measures and the lower portion of the red sandstone group. Organic remains will be of little assistance; neither is the mineralogical character of much avail, for it will be seen that this also changes."‡

And again he says :—

"A general unconformability does not always prove a movement in the inferior rocks prior to the deposition of the superior; for, supposing a given series so to be produced, the newer rocks may be formed within successively diminishing areas; and another deposit to cover the whole . . . this latter would overlap the various members of the former, as they successively fine off."§

Mr. Lyell gives the following opinions on this subject :—

"If we drain a lake which has been fed by a stream, we frequently find at the bottom a series of deposits disposed with considerable regularity one above the other. . . . . . If a second pit be sunk through the same continuous lacustrine *formation* at some distance from the first, nearly the same series of beds is commonly met with, yet with slight variations; some, for example, of the layers of sand, clay, or marl may be wanting, one or more

* Principles of Geology, vol. iii. pp. 38, 39.
† Geology, by Dr. M'Culloch, vol. i. p. 6.
‡ Manual of Geology, pp. 431—433.
§ Note to page 512, Manual of Geology.

having thinned out and given place to others, or sometimes one of the masses first examined is observed to have increased in thickness to the exclusion of other beds."

And again *mineralogically* :—

"These three classes of rocks, the arenaceous, argillaceous, and calcareous, pass continually into each other, and rarely occur in a perfectly separate and pure form."

"We may sometimes," continues the same writer, "follow a bed of limestone, shale, or sandstone, for a distance of many hundred yards continuously; but we generally find at length that each individual stratum thins out, and allows the beds which were previously above and below it to meet."

And finally from this author—

"The first observers were so astonished at the vast space over which they were able to follow the same homogeneous rocks in a horizontal direction, that they came hastily to the opinion that the whole globe had been environed by a succession of distinct aqueous formations, disposed round the nucleus of the planet like the concentric coats of an onion. But although, in fact, some formations may be continuous over districts as large as half of Europe, or even more, yet most of them either terminate wholly within narrower limits, or soon change their lithological character. Sometimes they thin out gradually, as if the supply of sediment had failed in that direction, or they come abruptly to an end, as if we had arrived at the borders of a sea or ancient lake, which seemed as their receptacle. It no less frequently happens that they vary in universal aspect and composition as we pursue them horizontally. For example, we trace a limestone for a hundred miles until it becomes more arenaceous, and, finally, passes into sand or sandstone. We may then follow this sandstone, already proved by its continuity to be of the same age, throughout another district a hundred miles or more in length."*

Professor Phillips states—

"The local variations in the series of the strata are considerable; several of the stratified rocks are only of limited extent; even whole formations, as the oolitic, change their characters, or, as the millstone grit, are entirely extinct in particular regions where the groups above and below them are complete.

"Another case of stratified deposits deviating considerably from the horizontal, may happen when carbonate of lime is precipitated from solution, and suffered to fall in very tranquil water, on a sloping or undulated bed. The thickness of the strata produced would be greatest in the deepest parts, and the whole deposit would grow thinner towards the edges."†

At a more advanced stage of this work, when it is shown how these rocky masses were elevated from the horizontal position in which they were formed, occasion will be taken to allude to several phenomena connected with this insensible junction of the strata which have evidently arisen from violent movement and

* Elements of Geology, pp. 6, 27, 64, 198.
† Treatise on Geology, pp. 40, 59, 60.

fusion. But the present observations are restricted to only such appearances of this kind as can be traced to the manner of their deposition.

I have been endeavouring to establish the fact, that the calcareous and carboniferous strata owe their origin, principally, to the propagation of inferior marine animals, and to the spread of imperfect flowerless plants from centres or foci of creation; and I have, therefore, merely to direct the attention to the form which extensive tracts of strata, proceeding from such sources would naturally assume, whose greatest density would be in their respective centres, to be fully persuaded that they would "thin out" as they approach their common limits, where they would blend entirely together, thus demonstrating in the cause of their accumulation, that also of their sectional form; whilst the arenaceous and aluminous beds associated with them, would be deposited from the fluid mass floating above; and as this impregnated mass extended alike over all, that which fell from it would, conformably to the laws regulating such depositions, be spread out in horizontal layers of considerable extent, whose upper surfaces would assume a perfect level by first filling up all inequalities of the base which received them. The simultaneous propagation of the testacea, conchifera, and zoophyta, and the spread of the cryptogamous and other imperfect plants, would present the appearance of slight elevations and depressions, having their higher parts at the centres, whence the animals and plants radiated; and it is therefore in strict accordance with the laws governing a fluid tranquilly depositing earthy sediment, to infer, that those depressions on the common original base would be gradually filled up by the deposition of layer after layer of earthy material. These afterwards amalgamating with the bounding strata around, would, when finally indurated, present the seeming anomaly "of a limestone bed gradually becoming more arenaceous until it eventually ended in a pure sandstone; or of a coal seam assuming an aluminous structure, and eventually ending in shale."

For a corroboration of this opinion, with regard to the manner in which a fluid mass, holding earthy sediment in solution, deposits this on the bottom, it may be opportune to extend the evidence already given, by the following extract from Professor Playfair's Illustrations of the Huttonian Theory* :—

"Loose materials," says that sagacious investigator, "such as sand and gravel, subsiding at the bottom of the sea, and having their interstices filled up with water, possess a kind of fluidity: they are disposed to yield on the side opposite to that where the pressure is greatest, and are, therefore, in some degree, subject to the laws of hydrostatics. On this account they will arrange themselves in horizontal layers; and the vibrations of the incumbent

* Chapter viii. pp. 320, 321.

fluid, by impressing a slight motion backwards and forwards, on the materials of these layers, will very much assist the accuracy of their level.

"It is not, however, meant to deny, that the form of the bottom might influence in a certain degree, the stratification of the sandstones deposited on it. The figure of the lower beds deposited on an uneven surface, would necessarily be affected by two causes; the inclination of that surface, on the one hand, and the tendency to horizontality on the other; but, as the former cause would grow less powerful as the distance from the bottom increased, the latter cause would finally prevail, so that the upper beds would approach to horizontality, and the lower would neither be exactly parallel to them, nor to one another."*

I have, with this, reached the limit of my present enquiries into the formation of the original stratiform masses of the earth; for the coal measures, with their associated limestone beds, are considered to have constituted the surface, or boundaries of the earth's outer crust, *during the period of non-rotation;* and that the superincumbent masses of more recent epochs owe their collocation to the effects of its first diurnal motion; consequently, whatever elucidation may be presented of that stupendous event, these newer formations must assume their relative places in it.

Before rotation took place, however, it seems apparent that successive formations of calcareous, carboniferous, aluminous, and arenaceous deposits succeeded each other, until the ocean was so far drained of its earthy material as to fit it for its ultimate state of equilibrium, and for becoming the pellucid "seas" of our day; and this the researches of geologists assure us actually was the case, as stated on the authority of those writers who have expressed concurring opinions.†

While these investigations have made it evident that the vast and continued operations then carried on were chiefly effected by the combined instrumentality of zoophyta, apulmonic animals, and of plants, whose labours having been performed *under water*, each of the creations of these organized beings, respectively, must have been of the description mentioned: and it has also been made manifest that they did perform the work they were called upon to execute; and, therefore, according to our ideas of an all-wise and beneficent Creator, no other classes of organic creatures, animal or vegetable, could by possibility have been employed for that purpose, consistently with the then incipient condition of the world.

I trust, therefore, it may be considered that I have now redeemed the pledge given at the commencement, to prove "*that during the period of the Earth's non-rotation, there were formed, and forming, under its waters, by the united instrumentality of mechanical deposition, of chemical and electrical action, and of animal and vegetable secretion and decomposition, those materials which were afterwards to constitute*

* Professor Playfair's Works, pp. 58, 59.

† See the ninety-seventh Theorem already recapitulated in a previous chapter.

part of its geological and meteorological phenomena; but which had not as yet assumed their present relative position, or their form. That the ocean was also undergoing the necessary preparation for its actual condition. And that the whole of these operations were going forward under the Divine influence, as recorded in the first chapter of Genesis."

In immediate connexion with this part of the subject I shall proceed to enquire, whether what has been said with respect to the deposition of earthy material in the form of strata, from a menstruum holding it in suspension, may not afford some clue to unravel what has hitherto been wrapped in mystery, and has occasioned much discussion. I mean the fact of the primitive ocean having entirely changed its character, from an aggregated mass of earth-impregnated *fresh* water into the present *salt* sea.

This attempt is beset with many difficulties, some of which are peculiar to itself, such as the meagre and sometimes equivocal character of the only evidence which can be brought forward to prove its *original freshness*. Nevertheless, confiding in the truth of what has been adduced, I shall commence by endeavouring to show *that the ocean has not always been salt, although from the first it contained within itself the elements of its saline constitution.*

By the concluding words of the *nineteenth* Theorem, it will be observed, "*that none of the plants discovered in the coal formations have been recognised as being of marine origin;*" while by one of the paragraphs of the *hundred and twenty-fifth* Theorem it is stated "*that in the green sandstone and the chalk, the few species of plantæ which have been found are principally marine.*" Let us proceed more closely to examine the authorities for these propositions; and in doing so, commence with an opinion given more than half a century ago, although, perhaps, geologically considered, it may not on that account be entitled to greater credit, yet it will serve to point out how *soon* these facts forced themselves into notice:—

"Now, since it appears," observes Mr. Whitehurst, "that all *strata* accompanying coal universally abound with vegetable forms, it seems to indicate that all coals were originally derived from the vegetables thus enveloped in the stone or clay; and we may say as much of the origin of iron; for the same *strata* also produce iron-stone: for wherever vegetables are observed to decay in stagnant ditches, the waters thereof appear ochory.

"It is a matter worth notice, that the superior *strata* contain ironstone, coals, and vegetable impressions, but NO MARINE PRODUCTIONS WHATEVER. And that the inferior *strata*, which are limestone, contain the *exuviæ* of marine animals, but NO VEGETABLE FORMS."*

"It was soon remarked," says Professor Henslow, at a much later date, "when the study of fossil vegetables began to attract the attention of botanists, that those from the coal measures were distinct from the plants now existing on the surface of the earth, and that they more nearly resembled the species of tropical climates than such as grew in the temperate

* Enquiry into the Formation of the Earth, London, 1786, p. 204.

zones. Subsequent researches have shown that the species imbedded in different strata likewise differ from each other, and that, on the whole, there are about fourteen distinct geological formations in which traces of vegetables occur. According to M. Brongniart, they first appear in the schists and limestones below the coal. These contain a few cryptogamic species (about thirteen), of which four are marine algæ, and the rest ferns or their allied orders. In the coal itself, above 300 distinct species have been recognized, among which those of the higher tribes of cryptogamic plants are the most abundant, amounting to about two-thirds of the whole. Many of them are arborescent, and parts of their trunks are found standing vertically in the spots where they grew. *There are no marine plants in this formation.* A few palms and some gramineæ are the chief monocotyledons; and there are several dicotyledons which have been considered analogous to apocyneaæ, euphorbiaceæ, cactæ, coniferæ, &c. No great stress need be laid at present upon the several proportions which species of these classes bear to each other; as it is probable that subsequent researches will considerably modify them. The great predominance and size of arborescent ferns and other tribes of ductalosæ constitute the main feature of the formation. . . . . . In the green sandstone and chalk few species have been hitherto found, and these are almost all marine."*

"It is a remarkable circumstance," says Sir Henry de la Beche, "connected with the coal measures of the south of England, that *marine remains have not been detected in them*, which, though it does not prove the deposit of coal to have been effected in fresh water, does appear to show that there was something which prevented the presence of marine animals, a circumstance the more remarkable as we have seen that such animals swarmed during the formation of the carboniferous limestone."

A little further on he adds—

"Let us now consider the mode in which the remains of *terrestrial vegetables*, so abundantly preserved in the coal strata, occur."†

"Mons. Ad. Brongniart," says Dr. Ure, "in his Treatise on the Classification and Distribution of Fossil Plants, comes to the following geological conclusions:—1. That in the formations of the coal and anthracite, the vegetables are almost all cryptogamia of the monocotyledonous tribe, such as filices (ferns), equisetum, lycopodiums, marsileaceæ, &c.; but the former three families included arborescent species, which no longer exist, except in the first. He therefore doubts the presence of palms in these strata. 2. That few vegetable remains are to be found in the great interval which separates these beds from the upper deposits, and that those which do occur belong almost wholly to marine plants, or to dicotyledonous trees, which appear to have been transported thither by inundations. And 3. That in the higher strata a great variety of fossil vegetables exist, which, for the most part, appear to belong to similar kinds of plants, if not in species, at least in genera, to vegetables which still inhabit the hottest regions of the earth; nor is it probable that they have been transported to our colder ones, since there are sometimes found, as in the lignite of Cologne, trunks of palm trees in a vertical position."‡

"Mr. Murchison infers," say the editors of the Literary Gazette, "that

* Botany, in Cab Cyc. pp. 311, 312.
† Manual of Geology, pp. 424, 427.
‡ New System of Geology, pp. 440, 441.

the coal measures of the great Dudley coalfields were accumulated exclusively in fresh water."*

"In the coal formation," say MM. Lindley and Hutton, "which may be considered the earliest in which the remains of land plants have been discovered, the flora of England consists of *ferns* in amazing abundance; of large *coniferous* trees, of species resembling *lycopodiaceæ*, but of more gigantic dimensions; of vast quantities of a tribe analogous to *cactæ* or *euphorbiaceæ*, but perhaps not identical with them; of palms and other monocotyledons; and, finally, of numerous plants the exact nature of which is extremely doubtful. Between two and three hundred species have been detected in this, the coal formation, of which two-thirds at least are *ferns*."†

"In England," says Mr. Miller, "the formation known as the quartzoze conglomerate is comparatively barren of fossils, the only organic remains yet detected in it being a single scale of the *holoptychius* found by Mr. Murchison; and though it contains vegetable organisms in more abundance, so imperfectly are they preserved, that little else can be ascertained regarding them than that they were land plants, but not identical with the plants of the coal measures."‡

It is certainly perplexing at the very outset to have to contend against a difficulty which occurs in the only *direct* evidence given upon the point now sought to be established. Professor Henslow's assertion, however, that "of thirteen species of cryptogames discovered in the schists and carboniferous limestone, *four* of them are marine plants," stands too directly in the way to permit of its being passed unnoticed.

In tracing the source from whence the several geological writers seem to derive the evidence for their statements relative to the flora of the primitive world, we are invariably led back to Mons. Ad. Brongniart, on whose researches and compilations they appear to have reposed great confidence; and hence it results that these various quotations merely tend to prove their united confidence in his judgment and researches; while, it is presumed, that he exercised the like confidence in MM. Sternberg, Schlotheim, Artis, &c., from whom, in turn, he derived much of *his* information. This, of course, must be considered sufficient; but still, on a point of so much importance in its bearing on our argument, it would have been more conclusive to have had concurring testimony from as many independent sources as possible. On the other hand it should be observed, that the whole number of species discovered in the schists and carboniferous limestone are rather limited, being only *thirteen*, but of which a third part are declared to be *marine*. Professor Henslow unfortunately does not say what these four marine exceptions consist of; and on referring to the copious lists of M. de la Beche, I find he has classed the carboniferous limestone in the carboniferous group, without noticing any *marine plant* in

* Literary Gazette, 21st May, 1836, p. 329.

† Vol. i. pp. x. xi.

‡ Old Red Sandstone, p. 196.

that series, and consequently the subject involves itself in additional obscurity. On tracing back, however, I discover that among the organic remains of the grauwacke group he has included three species of algæ, two of which have been found in Sweden, and one in Ireland, all apparently fucus-formed plants, and these may, perhaps, constitute the marine exceptions to which Professor Henslow alludes. Should this be the case, they must remain as they are until the enigma be explained by some of the numerous casualties which may have occurred to have placed three or four specimens of fossil plants in situations so ambiguous as to occasion their being attributed to the lower part of the carboniferous limestone, or even to the grauwacke group. On this particular point a remarkable coincidence occurs in the evidence just given from the standard work of Messrs. Lindley and Hutton, it being there stated that of the whole fossil flora which have been examined and classed by them, only four species of fucus-formed plants (fucoides) are specifically attributed to any formation associated with or below the coal measures, and they are in the transition series; most probably including the three species of fucoides referred by M. de la Beche to the grauwacke group of that series.

The reader, is, no doubt, aware that the termination "oid," borrowed from the Greek, is applied only when the object to be classed *resembles* but is not *identical* with the order or genus with which it is found convenient to group it provisionally. Consequently, when it is sought to determine, as accurately as possible, whether these four *fucoid* plants were the inhabitants of fresh or of salt water, the fact of their being thus merely allied to the fuci, leaves the question of their real *habitat* entirely open. And, certainly, where mistakes and misapplications in arranging organic remains according to geological epochs might, in spite of the utmost care and attention, so readily occur, and where a candid desire of the truth is brought to the discussion of subjects involving such general principles, an exception which, by assiduity, has been narrowed down to four species, and these merely analogous, ought not to stand in the way of the main body of the evidence being used in the future argument.

Considering, therefore, the coal measures themselves to have been wholly formed by the remains of *fresh water* plants, and to have constituted the grand centre of vegetable existence in the primitive world, they ought to form, as indeed they are intended to do, the principal basis of the argument. Besides, it is more consistent to suppose, that the development of the vast but progressive plan of Creation proceeded upon fixed principles, capable of adapting themselves to that progression, than to imagine it to have been subject to capricious changes from salt to fresh water, and from that again to salt. Even supposing it should be eventually established that during the early part of the coal formation, a few species of *fucoid* plants were

intermingled with those more purely of fresh water origin, it might be possible, on the well-ascertained capability of plants undergoing remarkable modifications of character without impeding any of their vegetable functions, to explain the anomaly by the supposition that plants so constituted, and, subsequently, found inhabiting the briny ocean, might have grown and flourished in a medium holding soda, lime, magnesia, sulphuric and muriatic acids in solution, but in different combination from what these ingredients are at present; although it may be utterly impossible to conceive that plants *decidedly of fresh water origin* could exist in the present water of the ocean, as these materials are *now* combined in association with them.*

I shall proceed, therefore, with the present argument upon the supposition that the ocean, during the earlier geological epochs, possessed all the properties of fresh water, as far as the nourishment of its vegetation was concerned, notwithstanding the presence of the ingredients just mentioned. Before proceeding, however, with this chain of argument, there is a *general* prefatory conception to which I am desirous of alluding, from its being essential to the thorough understanding of the subsequent reasoning. It is this: that like most of the other great aggregate bodies (the atmosphere, for example), which, taken together, make up the Earth we inhabit, the ocean, one of these bodies, has peculiar laws impressed upon it, which may, with perfect propriety, be called *constitutional.* That from these normal laws it never very greatly deviates, and to their subjection it has a constant tendency to return, even when deflected therefrom in any degree. That the water of the primitive ocean was gradually approximating towards this static condition during the non-rotatory period; and that, towards its termination, it had closely approached that state *which was to be for ever afterwards its natural condition;* from which the ocean would only partially, but never materially, deviate in future; and whose constituted power of stability would be such as to enable the sea-water to subdue any minor disturbing cause into obedience with the pervading laws of its constitution. The fixing of this principle in the mind will not only make what I have to say more easily understood, but will also serve to explain the equability with which the ocean throughout maintains its saltness; being neither rendered more so in mass by local evaporation, nor less saline by the emptying of rivers into it.†

* Theorem 122nd. Mr. Miller, with reference to this elasticity of character in plants, says, "the adaptation which takes place in the forms and constitution of plants and animals, when placed in circumstances different from their ordinary ones is equally striking. The woody plant of a warmer climate, when transplanted into a colder, frequently changes its ligneous stem for a herbaceous one, as if in the anticipation of the killing frosts of winter; and dying to the ground at the close of autumn, shoots up again in spring." (Old Red Sandstone, pp. 71, 72.)

† According to Mr. Reid, "the water of the Atlantic ocean within the tropics, contains 1-24th of its weight of saline matters; while that of the Firth of Forth is only reduced to about 1-30th." (Chemistry, p. 118.)

To this constitutional state, therefore, I consider the primitive ocean was gradually approaching, by the deposition of those ingredients which it had held in solution, to facilitate their chemical combination with each other; while it also conveyed them from place to place in obedience to the will, and in conformity with the plans, of the Omnipotent. The carrier-ocean itself being likewise thereby prepared to assume that clear and sparkling state which renders it at once the most beautifully grand, the most wholesome, and the most useful element in nature. Nor can I recognize any objection to this view of the case; or any reason why it should not be admitted that the ocean required to undergo a course of preparation for being rendered capable of executing *its* part, any more than that the solid strata, born of it, should require to have been perfected in order to fulfil *their* part in the unfolding plan of the Creation. On the contrary, I consider it peculiarly characteristic of the great source from whence they all originated when we perceive two effects springing simultaneously from one cause, the one co-operating towards the perfection of the other. The ocean approaching nearer and nearer to its own maturity in proportion as it parted with the stony concretions which were forming within its bosom by the several combinations alluded to, while they, as they were being deposited—crust after crust of mineral strata—were destined, in turn, when they should be elevated, to become solid defences to the terraine portions of the world, to protect them against the future encroachments of the very element from whence they emanated.

It may be remembered, that at the commencement of these investigations into the nature of the deposits which, in all likelihood, were taking place from the primitive ocean, it was considered that silex, alumina, lime, magnesia, barytes, strontites, zirconia, glucina, potash, soda, and ammonia; oxides of various metals, especially iron and manganese, carbonic and fluoric acids, hydrogen and oxygen, with muriatic, sulphuric, and nitric acid, were the ingredients held by the ancient water in chemical combination.

In continuation, it was explained, first, that by the abstraction of those elements which are known to have been taken from it by animal and vegetable agency; and, afterwards, by the infusion into it of several gaseous exhalations, arising from the decomposition of the animal and vegetable bodies, successive alterations of its equilibrium must have taken place, so as to have brought about new combinations, and to have caused insoluble precipitates which, in time, became mineral stratiform masses, encrusting the bottom of the ocean. And in this way there was accounted for, the locking up, in these stony concretions, of the silex, alumina, barytes, strontites, zirconia, glucina, oxides of iron and manganese, fluoric, carbonic and nitric acids, and part of the lime and magnesia; consequently there are now only to be accounted for the residue of the magnesia and of the lime, as well as the soda, potash, and ammonia,

and the sulphuric and muriatic acids which remained after the others had become solidified and insoluble.

When the earthy and metallic substances preserved the relationship which has been described, to the muriatic, sulphuric, and nitric acids, and, by their superior affinity towards these acids, excluded the alkalies which, in turn, would combine, by *their* affinities, with the carbonic acid, *the oceanic water, would not, it is presumed, have possessed the saline taste and properties which it does at present;* because it has those properties, in our day, by the presence of the muriates of soda, magnesia, and lime, and the sulphate of soda, which it holds in saturation in certain determinate proportions, the muriate of soda, or culinary salt prevailing greatly over all the others. But as soda could not then have been in combination with muriatic acid—it being an axiom in chemistry that an acid will affect the saturating principle in proportion to the strength of its affinity; so, therefore, neither could the taste and qualities which that combination alone confers have been present—hence it may be looked upon, without much fear of being wrong, *that up to the time of the carboniferous era, the primitive ocean was not salt.* Moreover, as the substances dissolved in it were held in *chemical* combination, they would, even though in great abundance, detract very little from the limpidity of the water.* Those two essential conditions will account for the possibility of its abounding with *fresh water* plants, in accordance with what is stated in the concluding part of the *nineteenth* Theorem. Neither is this state of matters greatly at variance with what occurs at the present day, for it will be observed by the *hundred and tenth* Theorem, *that, besides pure water, the most common ingredients in mineral springs are carbonic acid, sulphuretted hydrogen, carbonates, sulphates, and muriates of soda, of lime, and of magnesia, and carbonate and sulphate of iron. And those of more rare occurrence are sulphurous acid, nitrogen gas, sulphate of alumina, muriate of manganese, siliceous earth, fluoric acid, lithnia, strontia, potash, and hydriodic acid. That as mineral contents are in chemical solution, they rarely, even when in great abundance, affect the clearness of the water. That to hold a large quantity of silex in solution, it seems requisite that the water should be raised to a high temperature. And that, notwithstanding their mineral character, and the high temperature of some of the springs, confervæ and other plants thrive in and close around them.*

Thus I have fulfilled the promise made when treating of the ancient flora, to prove that, although the water of the ocean contained, from the beginning, the elements which confer on it its saline taste, *yet it was not salt, but fresh,* up to the period when geology can prove, "that the whole of the carboniferous plants were of fresh water origin." Having done this, I must now, in continuation, endeavour to show how the ocean assumed its present saline condition.

* Lyell's Principles of Geology, vol. i. p. 227. Vide also any analysis of mineral waters.

What has already been stated will have prepared the mind for entering upon this explanation; for I have accounted for the locking up of nearly the whole of the carbonic acid in forming the shelly coverings of the inferior animals of the primitive era, and in the nourishment afforded to its flora. During the same period, we have seen that immense deposits of lime took place, not only in completing these coverings, but also in forming the calcareous cement discoverable everywhere in the limestone strata; and that the same must, likewise, have occurred with respect to silex, magnesia, and alumina. We were, also, made aware that the introduction of ammonia precipitated the alumina which constitutes the slaty and shaly formations, which, in turn, gave occasion to other changes, causing the simultaneous deposit of more silex, and of magnesia; while phosphuretted hydrogen performed the same office towards the metallic oxides. That barytes and strontites, from being light and soluble compounds, in union with muriatic and nitric acids, on becoming associated with carbonic and sulphuric acids, were precipitated as the most ponderous of the rocky masses. That fluoric acid holding silex in solution, seems to have entered into the composition of the micaceous deposits which frequently accompany the porcelain earths.* And, lastly, it was shown, on sufficient authority, that earthy precipitates, on being thrown down by the agency of an alkali, generally carry a small proportion of their acid associate along with themselves.

Having in this way accounted for the purification of the primitive water by being deprived of these earthy, metallic, and acidulous ingredients, it will be seen by instituting a comparison between the precipitates above enumerated and the ingredients which the water was considered to have contained at the commencement, that there remain only to be accounted for, the residue of the lime, magnesia, soda, potash, muriatic and sulphuric acids; and the ammoniacal gas which must have arisen from the putrefactive decomposition of innumerable races of marine animals, during a long but indefinite period; even although a considerable portion of this buoyant gas would be intercepted, in performing other services on its way to the surface.

In conducting the remaining enquiry I shall endeavour, first, to dispose of the *volatile alkali*, which, from its low specific gravity, possesses the peculiar property of conferring on the water a lesser specific weight than it had previous to imbibing it. On a point so essential to the future argument, I should wish to base this fact on the securest evidence. Attend, therefore, to what Drs. Murray and Ure state on this point:—

"Ammoniacal gas," says the former, "is largely and rapidly absorbed by water; the water, under a mean atmospheric pressure and temperature, taking up, according to Sir H. Davy, 670 times its bulk of this gas, and acquiring a specific gravity of 0.875. According to Dr. Thompson, water

* Ure's Chemical Dictionary, p. 331.

takes up even 780 times its bulk of ammoniacal gas. Its solution, in water, is of inferior specific gravity to pure water, being usually from 0.900 to 0.936. This gas is expelled from it by elevating the temperature to 136°."*

"The specific gravity of ammonia," says Dr. Ure, "is an important *datum* in chemical researches, and has been rather differently stated. Yet, as no aeriform body is more easily obtained in a pure state than ammonia, this diversity among accurate experimentalists shows the nicety of this statistical operation. MM. Biot and Arago make it 0.59438. Kirwan says that 100 cubic inches weigh 18.16 gr. at 30 ins. of bar., and 61 of Far., which, compared to air reckoned 30.519, gives 0.59540. Sir H. Davy determines its density to be 0.590, with which estimate the theoretical calculations of Dr. Prout, in the 6th vol. of the Annals of Philosophy, agree. . . . . . Water is capable of dissolving easily about one-third of its weight of ammoniacal gas, or 640 times its bulk."

Dr. Ure, after referring to a table "of the quantity of ammonia in 100 parts, by weight, of its aqueous combinations at successive densities, as given in the Philosophical Magazine for March, 1821," and which in general shows a lower specific gravity than pure water, ranging from 0.9000 to 0.99447, goes on to say:—

"The remarkable expansiveness which ammonia carries into its first combination with water, continues in the subsequent dilutions of its aqueous combinations. This curious property is not peculiar to pure ammonia, but belongs, as I have found, to some of its salts. Thus, sal ammoniac, by its union with water, causes an enlargement of the total volume of the compound, beyond the volume of the constituents of the solution, or the specific gravity of the saturated solution is less than the mean specific gravity of the salt and water. I know of no salts with which this phenomenon occurs, except the ammoniacal."†

The fact of the specific gravity of water being reduced, when combined with ammonia, or with its salts, is a remarkable evidence of the all-pervading wisdom of the Creator; for it will be remembered that its introduction into the primitive water, when in equilibrium, became the prime mover of many of the chemical changes which followed, while as its chief action was directed to the aluminous and magnesian earths dispersed throughout the water, in this diminution of specific gravity an adequate provision was made for its ascending through, and searching the whole of that world-wide mass of liquid; so that none of the parts might escape its penetrating and precipitating influence. And, lest it should be detained in its upward progress—where it was destined long afterwards to act an important part in the future plans of the Creator, a weaker affinity was conferred upon it for the acids which remained, than was bestowed upon the potash, the soda, the lime, or the magnesia, all of which, as has been already shown, rob ammonia of its acid associates wherever they find them united; and thereby it was left free

* Elements of Chemistry, vol. ii. p. 13.
† Chemical Dictionary, pp. 148, 149.

to pursue its upward tendency.* Hence it may be considered as a legitimate conclusion, that the ammonia, whose low specific gravity, either when pure or when combined with water, caused it to arise in exhalation from putrefying animal substances at the bottom of the ocean, enabled it to continue its course uninterruptedly, while it performed the chemical duties imposed upon it, nor stopped until it reached its destined position amongst the uppermost liquid strata of the primitive ocean, there to await the future designs of the Omnipotent.

The disposal of the ammonia, leaves us to deal with the following materials only, all of which, according to the best received opinions, would be combined in the water in their most soluble states, viz., soda, potash, lime, magnesia, and muriatic and sulphuric acids; ingredients which confer on sea water its peculiar saline constitution, as will be seen by referring to part of the *ninety-first* Theorem, which states: "*That, by repeated analysis, sea water has been found to consist of the following ingredients in every* 500 *grains, namely,* 478.420 *of pure water;* 13.300 *muriate of soda, or culinary salt;* 2.333 *sulphate of soda;* 0.995 *muriate of lime;* 4.955 *muriate of magnesia. Wherefore, the ocean, besides the elements of pure water, contains muriatic and sulphuric acids, soda, magnesia, and lime, together with traces of iodine, bromine, and, occasionally, potash.*"

A more detailed examination of the evidences for this conclusion, gives us the following particulars:—

Sir H. de la Beche states, that "according to Dr. Marcet, 500 grains of sea water, taken from the middle of the North Atlantic, contained,

Muriate of soda	13.300
Sulphate of soda	2.300
Muriate of lime	0.995
Muriate of Magnesia	4.985
	21.580."†

Dr. Ure, in his comprehensive table of mineral waters, gives for sea water the following results, viz.:—

	GRAINS.		GRAINS.
Water	7291	Muriate of lime	5.7
Muriate of soda	159.3	Sulphate of soda	25.6
Muriate of magnesia . . .	35.3	Sulphate of potash . . .	a trace‡

Dr. Murray says, that sea water, on the principle that the most soluble salts will be those existing in solution, will contain in a pint,

Muriate of soda	159.3	grains
Muriate of magnesia . . .	35.5	,,
Muriate of lime	5.7	,,
Sulphate of soda	25.6	,,§

* Ure's Chemical Dictionary, p. 184, and Dr. Murray's Elements, vol. ii. p. 15. Nisbet's Chemistry, and Table of Affinities from Dr. Pearson's Chemical Nomenclature.

† Geology, p. 3.

‡ Chemical Dictionary, p. 280.

§ Elements of Chemistry, vol. ii. p. 396.

Finally, as regards the evidence on this point, although it may, in some degree, be an early anticipation, I can hardly pass onwards without alluding to another concurring cause, namely, the introduction of the primary light into the material universe on the first day of the Mosaic week, whose electrical effects would thereafter tend, perhaps, more than any other influence, to complete the perception of saltness by means of the pre-existing saline elements.

Having thus reached a point where the argument *a priori* coincides with the conclusions of experience, deduced from actual analysis of sea water, I trust it may be considered that the steps which have led to it have also been correct. When we reflect on the progressive character of the process which transformed the ocean, from a boundless reservoir of earthy mineral water, with its saline ingredients and properties neutralized by the presence of substances possessing greater affinity for the acids than the fixed alkalies, whose union with them is now the cause of its saltness; and, at the same time, consider that the deposition of these earthy materials, which now form the rocky beds of the earth's outer crust, extended in duration from the earliest geological epoch wherein regular strata can be detected, up to the latest of the coal measures, and that these stupendous depositions were many ages in being effected, we have every reason, also, for concluding, that the sea acquired its saltness by degrees, and, therefore, that the successive families of plants would correspond, in every respect, to the predominant constitution of the element during that particular period in which each was destined to grow; while, as an evident deduction from these truths, the final conclusion may be come to, that *marine plants*, or those most resembling them, such as the fucoides, would be discovered only amongst the *latest* series of the coal measures, or imbedded in some of those above them, such as the tertiary strata, which are of still later formation.

Before quitting this portion of my labours, and whilst the circumstances are fresh upon the mind which bring out, so clearly and delightfully, the wisdom which devised, and the power and skill which wrought out these beneficent ends by such numerous and humble instruments, through protracted ages and on a scale so vast, we cannot more appropriately offer up the tribute alike of our adoration and our thanksgiving, than by adopting the language of the Psalmist, and proclaim with one voice, "The sea is his, and he made it; and his hands formed the dry land. O come let us worship and bow down, let us kneel before the Lord our maker. For he is our God, and we are his people!"

SECTION IV.

INTRODUCTION OF THE LIGHT; THE CONSEQUENT PROTOROTATION OF THE EARTH; AND ITS DYNAMICAL RESULTS.

CHAPTER XIII.

Prefatory observations. Condition of the Earth during the period alluded to. Introduction of Light into the material universe. Contrast between the prolonged operations of the non-rotatory period and the sudden completion of the work of creation during the Mosaic week. The relative qualities of Light—its cuasi-ubiqnuity, expansion through visible space, velocity of propagation, and vividity. Heat the cause of expansion in material bodies. The source of external Light and Heat received by the Earth. Identity of these two subtile influences. Sunlight the direct cause of Heat. Attraction and Expansion the antagonistic forces which maintain all matter in its constitutional state of equilibrium. Deduction from these facts, that Darkness means Attraction. Scientific analogies in favour of the same conclusion.

At the period to which allusion was made towards the close of the last section, the earth was considered to have been a spherical planet, whose horizontal rocky stratified crust—beneath a dark and atmosphereless ocean—was covered in some places by dense vegetation, and in others teemed with inferior animal life; while the primeval water, though drained of its metallic ingredients, and most of its suspended earths and acids in forming those strata, still retained some of the two latter, and a proportion of the original alkaline and acidulous elements: and that, thus constituted, the earth was looked upon as circulating round an unillumined sun, in obedience to the same laws which still govern its periodical motion; and in precisely the same orbit wherein it continues to perform its annual revolution.

The great movements of the orbs in space had, long ere the period alluded to, reached a state of equilibrium, from which nothing but a fiat from the Omnipotent can ever cause them to depart; but, as regards the earth itself, it is to be borne in mind, that according to the same immutability of the laws which govern every particle of matter, the primeval water might, by a continuance of the purifying process, if it had so pleased Heaven, have gone on parting with elements until it became inconceivably more aeriform than it ever was destined to be. Still, being material, even under these imaginary circumstances, it would have reached a point, and have assumed a state of equilibrium, from which, until the laws were changed, it could not possibly have departed. For without the direct and opportune interference of a power beyond itself, and of adequate influ-

ence, the non-rotating earth, with all its concentric stony encrustations, its myriads of living beings, with its dense sub-marine fields of gigantic plants, and its limpid, but dark atmosphereless water, must have continued for ever to have circulated, in annual orbit, around the unillumined sun, without any further progress having been made in the work of Creation. A little more attention and assiduity will, however, bring us to a point where we shall perceive that the world was not destined to be left in this unfinished condition; but that God, from everlasting, had foreseen this exigency; and did, in due time, *by the creation of the light*, introduce into the material universe a power sufficient to impel the work onwards until it was completed.

With these prefatory observations—which are intended to prepare the mind—I shall proceed with the further development of the views intended to be brought out; and adhere, as closely as possible, to the same method of unfolding them.

The condition described at the beginning of this chapter, is that in which the earth is considered to have been while, in the impressive language of Scripture, "darkness was upon the face of the deep;" and it continued in the same state until every atom of superfluous earth was precipitated from the water, and the last plant or creature had fully executed the object for which it was brought into existence. For such is the manifest design prevailing throughout the whole, and so minute the superintending care of the Creator, that the strongest conviction is impressed upon the mind, that whilst a single grain of silex, intended to aid in the formation of any of the numerous stony concretions at the bottom of the ocean, had not as yet been separated from the water, and placed by crystalization in its destined position, no change would be commanded to take place in the great governing laws of the universe; while, on the other hand, whenever the last particle had subsided, we believe that not one instant of time would elapse until the fiat went forth which should change the whole face of Creation; and the material universe, from an unillumined congeries of spheres, revolving in the dark womb of nature, should be transformed into a radiant galaxy of worlds, shining in the beams of the newly-formed light, and rejoicing in all their pristine purity and loveliness.

In prosecution, therefore, of the subject, it is now to be considered that the moment had arrived, foreseen from all eternity, when plants and animals had—for the time being—alike fulfilled their destined functions, and the last material particle designed to be separated from the primitive water, and aggregated to the solid earth beneath, had reached its destination, and the august command, "Let there be light," was resounding throughout the universe; sufficiently vouched for by the obedient response which immediately follows, "And there was light." After dwelling for a moment with feelings of admiration and astonishment on what-

ever can be comprehended of the attributes and power of that Being who could thus command and be obeyed by all nature; and filled with love for the unbounded goodness which caused such a gracious act of volition, let us endeavour to determine the results of this important and transforming announcement on the state, the motions, and the materials of the hitherto non-rotating, watery-bound sphere, "without form and void;" but which, with pleasing variety of hill and dale, of land and water, and in the enjoyment of the vicissitudes of day and night, and summer and winter, now forms the mighty pedestal whereon myriads of beings, adapted to its altered condition, are wheeled with rapid but unconscious speed through the prescribed regions of space.

In attempting this arduous undertaking, the conceptions which crowd upon the attention are so numerous, and have reference to so many and to such stupendous operations, that they almost overwhelm, and leave the mind in a condition to be scarcely able to deal effectually with any of them.

Hitherto these investigations have had reference to works carried on throughout a period of long duration, but of so progressive a character that leisure was afforded for careful examination, as the work went on, step by step, towards perfection; and composure was enjoyed to note down the successive events which were taking place beneath a shoreless ocean, and upon a motionless sphere, where all was still and slowly progressive. But from the time now referred to, when the prime mover, LIGHT, was introduced amongst the materials which had thus been prepared, the whole aspect of creation suddenly changed, and events of transcendental importance succeeded each other with astounding rapidity. Those elements, which had been the work of ages to create, were now, within the limited space of six days, to be all remodelled, fashioned, and framed, and made to occupy the relative positions on the land, in the sea, and throughout the air, for which they had been designed from all eternity! Where darkness reigned almost paramount before, material light was introduced to be its powerful and active competitor. The dark, slumbering, shoreless ocean was made to rush, wave over wave, with impetuous haste, from the poles towards the equator, so soon as the finger of God, by causing the earth to rotate, had marked off those points, hitherto non-existent, upon the surface of the non-rotating sphere; while the great continental ridges of the world, raised their huge backs from beneath part of that agitated ocean to restrain it in future within the hollow cavities which simultaneously sank down in obedience to the Creator's will. And the elements of the atmosphere, ejected far into space by the same proto-motion, were there transfixed by their decreed union with light, and never allowed to return; but there retained, as the life-sustaining atmosphere.

LIGHT, however, the chief secondary agent in producing all these

wondrous effects, is that to which I would, at present, more particularly direct the attention.

It is not intended to enter into any discussion as to the *intimate* nature of the light, which, on the first day of the Mosaic week, was willed into existence. Yet it is considered to have been akin to the invisible light and heat which can be excited by *electrical agency; that* powerful but imperceptible fluid, for example, which results by completing the voltaic circuit, and that not until the *fourth* day of the Mosaic week did *visible* light exist. It is also assumed that whatever may have been the nature of light, it was *complete in itself, on the first day before* it was divided from the darkness; that there were, therefore, two separate and sequent acts of creation with respect to this important element: one whereby *light* was willed into existence, and caused to pervade all materialism; and another whereby a certain *state* or *condition*, distinct from its *intimate* nature, was conferred upon it, by its being "divided from the darkness." And, finally, it is conjectured that the light, in this latter condition constitutes, an indispensable element in the existence of all organised beings throughout the material universe, possessed of a nervous system, and dependent on this and atmospheric air for their powers of locomotion. That, in fact, it formed the great base or groundwork preparatory to the introduction of all such animated beings, which could no more have performed their nervous functions without this all-pervading element, than they could continue their respiration independently of the atmosphere. This fundamental fluid being all throughout and everywhere the same, the diversity of the creature consequently consists in the modification of *its* nervous system and form.

The words "Let there be light: and there was light," have usually a signification applied to them almost exclusively of *power*. But, besides the incontestable evidence of Omnipotency which these passages so clearly display, they, at the same time, convey a meaning equally as wonderful by the Ubiquity of the *light* which they make so manifest. It is considered that the element, recorded to have been formed on the *first* day of the Mosaic week, is the most *immaterial* of all material substances which were created. I am well aware of the difference between materialism and immaterialism, and have no intention of confounding them; it is merely wished to convey, by these assertions, a conception of the tenuity, subtility, and buoyancy of light. It was the Creator's chief agent, of a material kind, in accomplishing the six days' work recorded in the Mosaic narrative; and, before it was created, a "movement on the face of the waters" produced effects which, although material light could not have done, yet were they entrusted to this latter agent, for ever afterwards to be continued and preserved in the condition to which they were brought by more immediate influence. And, in continuation, I may express my belief, that the Light to which

allusion is now made pervades all materialism; that there are not any two points, however remote from each other, in the universe, which have not the space between them filled up with light; while its penetrating minuteness is the admiration of all who have paid any attention to its wonderful developments.

But let these general assertions be verified by evidences derived from science. The *thirty-eighth* Theorem thus describes this subtile influence:—

"*Light, according to the Newtonian hypothesis, is supposed to consist of inconceivably minute material particles, emitted by luminiferous bodies, and moving through space with the velocity of* 192,000 *miles in a second of time. That, according to the Undulatory Theory, an exceedingly thin and elastic medium called* ETHER *is supposed to fill all space, and to occupy the intervals between the particles of material bodies; and that the vibrations or undulations of this etherial medium cause the sensation of* LIGHT.

"*But whatever may be the mode by which it is considered that light becomes perceptible, its universality, and the almost immeasurable distance at which it is perceived throughout space, as well as the amazing rapidity of its vibrations requisite to convey sensations of colour, are alike remarkable.*"

In selecting the evidences, I shall, for the present, dwell more especially upon those which refer to the *ubiquity* of light, whether as regards its universality throughout space, or its searching penetrability and minuteness. Upon its velocity and intensity a few passages will suffice, and these shall be first submitted.

Sir David Brewster states—

"That light moves with a velocity of 192,500 miles in a second of time. It travels from the sun to the earth in seven minutes and a half. It moves through a space equal to the circumference of our globe in the eighth part of a second; a flight which the swiftest bird could not perform in less than three weeks."*

Mrs. Somerville observes—

"This circumstance (namely, a difference in the time of the eclipses of the satellites of Jupiter, according as this planet is in conjunction or in opposition), is attributed to the time employed by the rays of light in crossing the earth's orbit, a distance of about 190,000,000 miles; whence it is estimated that light travels at the rate of 190,000 miles in a second."†

Sir John Herschel says—

"Roemer (a Danish astronomer, in 1675), speculating on the probable physical cause of the difference in the times of the eclipses of Jupiter's satellites, was naturally led to think of the gradual, instead of an instantaneous propagation of light. This explained every particular of the observed phenomenon, but the velocity required (192,000 miles per second), was so

* Optics, Cab. Cyc. p. 2.

† Connection of the Sciences, pp. 37, 38.

great as to startle many, and, at all events, to require confirmation. This has been afforded since in the most unequivocal manner."*

It is stated in the "Connexion of the Sciences," with reference to the intensity of this subtile element, that—

"The intensity of light depends upon the amplitude or extent of the vibrations of the particles of ether; while its colour depends upon their frequency. The time of the vibration of a particle of ether is, by theory, as the length of a wave directly, and inversely as its velocity."

And after describing the delicate and ingenious method employed by Sir Isaac Newton, and others, to compute the frequency of these vibrations, it is further said—

"Now, as Sir Isaac Newton knew the radius of the curvature of the lens, and the actual breadth of the rings in the parts of an inch, it was easy to compute that the thickness of the air at the darkest part of the first ring is the 1-89000th part of an inch, whence all the others have been deduced. As these intervals determine the length of the waves on the undulatory hypothesis, and as the time of a vibration of a particle of ether producing any particular colour is directly as a wave of that colour, and inversely as the velocity of light, it follows that the molecules of ether producing the extreme red of the solar spectrum perform 458 millions of millions of vibrations in a minute of time; and that those producing the extreme violet accomplished 727 millions of millions of vibrations in the same time. . . . . The determination of these minute portions of time and of space, both of which have a real existence, being the actual results of measurement, do as much honour to the genius of Newton as that of the law of gravitation."†

"According to the undulatory theory," says Sir David Brewster, in the Treatise on Optics, an exceedingly thin and elastic medium, called ether, is supposed to fill all space, and to occupy the intervals between the particles of all material bodies. The ether must be so extremely rare as to present no appreciable resistance to the planetary bodies which move freely through it.

"The particles of this ether are, like those of air, capable of being put into vibrations by the agitation of the particles of matter, so that waves or vibrations can be propagated through it in all directions. Within refracting media it is less elastic than in vacuo, and its elasticity is less in proportion to the refractive power of the body. When any vibrations or undulations are propagated through this ether, and reach the nerves of the retina, they excite the sensation of light, in the same manner as the sensation of sound is excited in the nerves of the ear by the vibrations of the air. Differences of colour are supposed to arise from differences in the frequency of the ethereal undulations; *red* being produced by a much smaller number of undulations in a given time than *blue*, and intermediate numbers of undulations.

"In a work like this it would be in vain to attempt to give a particular account of the principles of this theory. It may be sufficient at present to state that the doctrine of interference is in complete accordance with the theory of undulation.

"The following table, given by Mr. Herschel, contains the principal data of the undulatory theory:—

* Astronomy, Cab. Cyc. p. 466.

† Pp. 190—193.

Colours of the Spectrum.	Length of an undulation in parts of an inch.	Number of undulations in an inch.	Number of undulations in a second of time.
Extreme red	0.0000266	37,640	458,000000,000000
Red	0.0000256	39,180	477,000000,000000
Intermediate	0.0000246	40,720	495,000000,000000
Orange	0.0000240	41,610	506,000000,000000
Intermediate	0.0000235	42,510	517,000000,000000
Yellow	0.0000227	44,000	535,000000,000000
Intermediate	0.0000219	45,600	555,000000,000000
Green	0.0000211	47,460	577,000000,000000
Intermediate	0.0000203	49,320	600,000000,000000
Blue	0.0000196	51,110	622,000000,000000
Intermediate	0.0000189	52,910	644,000000,000000
Indigo	0.0000185	54,070	658,000000,000000
Intermediate	0.0000181	55,240	672,000000,000000
Violet	0.0000174	57,490	699,000000,000000
Extreme violet	0.0000167	59,750	727,000000,000000

"'From this table,' says Mr. Herschel, 'we see that the sensibility of the eye is confined within much narrower limits than that of the ear; the ratio of the extreme vibrations being nearly 1.58 : 1, and therefore, less than an octave, and about equal to a minor sixth.

"'That man should be able to measure with certainty such minute portions of space and time is not a little wonderful; for it may be observed, whatever theory of light we adopt, these periods and these spaces have a *real existence*, being, in fact, deduced by Newton from direct measurements, and involving nothing hypothetical, but the names here given them.'"*

These evidences, as to the velocity, intensity, and the minuteness of the vibrations of light, must now be followed up by some extracts regarding its wide-spread expansion throughout space.

The author of the *Architecture of the Heavens*, in his impressive language, says—

"The nebulæ, whose general aspect I am about to describe, present very various appearances to the telescope. In many of them individual stars are distinctly defined. As they become more remote, the distance or intervals between the stars diminish, the light also growing fainter; in their faintest stellar aspect they may be compared to a handful of fine sparkling sand, or as it is not inaptly termed, "star dust;" and beyond this we see no stars, but only a streak or patch of milky light, like the unresolved portions of our own surrounding zone. . . . . .

"It was a bold conception, after having recognized the great meaning of these nebulæ, to undertake to compute their relative distances, and to lay down their plan. But, undaunted even by the idea of the firmamental universe, Herschel undertook to fix what it was within reach of his telescopes, and of course, what it might be beyond them. . . . . . . By using comparatively small telescopes he determined the remoteness of 47 resolvable clusters, *ten* of which were upwards of 900 times more distant than Sirius. Suppose a cluster as ascertained to be of the 900th order of distances were

* Optics, Cab. Cyc. pp. 134—136.

first seen by a telescope whose space-penetrating power is 10, it is easy to compute how far off it must be to be descried as a faint speck by an instrument whose power is 200—it would evidently be at the enormous remoteness of 18,000 times that of Sirius! Very many unresolved clusters are undoubtedly as profound, and many still profounder in space. . . . . . . Herschel reaches the depth of the 35,175th order of distances, in which some of these nebulæ must be. . . . . A forty feet reflector could descry a cluster of stars, consisting of 5,000 individuals, were it at the remoteness of 11,765,475,948,678,678,679 miles, and in fact, the limits to the power of such an instrument being only *an object fainter than the general light of the skies constituted by the intermingling of the rays of all the stars.*

"We, of this time, may do little more than roughly chart the boundary line," of the vast firmament; "the filling up and mapping of the details constitute a harvest for the future. But how soon may that future come! The wheels of time are revolving rapidly—truth mingling with truth, as light gathered into a focus—alike within and around us, cause events to succeed without the usual interval; nor is astronomy unaffected by the general acceleration. . . . . . What triumphs, what delights are awaiting us; yet once more shall new views dawn upon mankind; yet once more will some favoured eye first track a vast unknown."*

More conclusive evidences than these, of the almost immeasurable expansion of light throughout the universe, or of the extreme rapidity of its vibrations, need scarcely be desired. Indeed, the tongue can hardly repeat the numbers which the foregoing array of figures denotes, nor the mind imagine the almost illimitable immensity of space to which they have reference; while it should be remembered, that, as far as the human eye—armed with the most powerful lenses—is concerned, these vast distances at which luminous objects are visible—these vanishing points of light—extend in every direction, as from a centre, around our mundane spec, that they are as remote in every quarter of the heavens as in any one region!

Nothing appears wanting, therefore, to show the universal diffusion of light; or the almost inconceivable velocity of its undulations, whereby it seems to shrink, as it were, as far from our perception by *minuteness*, as it spreads itself throughout space *in extension*. And this having been satisfactorily established, I have next to combine it with the no less certain fact of its having *been complete in itself before* that *state* or *quality* which divides it from the darkness was impressed upon it. And here I may observe, that the boundless stores of SCIENCE, varied and delightful as they are, may be ransacked in vain without imparting to us the slightest information on this particular point. Yet we know, upon the irrefragable authority of him who formed it, that such was the case. That there was a time—however evanescent—when the LIGHT, *before* it was divided from the darkness, was complete and whole in itself, and lacked nothing. It *was* light, but quiescent light, as yet undivided

* Architecture of the Heavens, Nichol, 1837, pp. 48, 54, 39, 102, 103.

from the darkness; for it is recorded, where no mistake can occur, that in that condition, "it was good." And therefore, as a correct inference from these positions, there can be laid down the two bases, *that there was an instant of time when the light, though complete, was without motion, and that, as near as matter can be, it is ubiquous.*

Holding these two dominant qualities of light steadily in the mind, and pondering over their united effect upon the act of conferring motion upon that subtile element, it is impossible to come to any other conclusion than *that the motion impressed upon it would be one of* VIBRATION *or* UNDULATION. For it can be easily imagined that throughout any space, however vast, which is completely filled by an elastic medium, eminently ethereal (and the more ethereal the greater tension and effect), a vibratory motion may, when engendered, be propagated and transmitted with the utmost rapidity. But it seems wholly inconceivable, on anything like philosophical principles to imagine that *particles of matter*, although ever so minute, subtile, or penetrating, which, *before* motion was communicated to them, filled all space, could be *made to travel* through the identical space which was filled with them previously!

This brings us a stage nearer to the point at which I wished to arrive; and leads to a further and more important consideration of the same combination, namely, the *ubiquity* of the ethereal element, and the fact that *there was a time*, however brief, when light *existed, complete in itself, but without* having been divided from the *darkness.*

The results arising from these positions will, on investigation, be found to have been most momentous. The introduction of this new force into the material universe, as the first act of creative power during the Mosaic week, amongst materials which it had required ages to prepare for its reception, will show us, as the enquiries proceed, *that light, and especially its ubiquity and its division from the darkness, caused it to become the prime material mover in almost all the stupendous operations of that eventful week, which were designed, from everlasting, to follow in the sequence in which they stand recorded.*

The first point in this new chain of argument is to prove, that the presence of *heat* and *light* invariably causes expansion.

In effecting this I shall commence by recapitulating what is contained in the *fiftieth* Theorem, "*That the first and most usual effect of heat is to increase the size of the bodies to which it is imparted, by causing them to dilate or expand. That, although these effects are produced in different degrees and by different methods, according as the body to which heat is applied be solid, liquid, or aeriform, yet it may be considered as a physical law to which there is no real exception, that an increase in the temperature will be accompanied by an increase of volume, and a diminution of temperature by diminution of volume. And that the force with which solids and liquids expand or contract by heat or cold is prodigious.*"

In another part of the work from which this is taken it is added—

"We have seen that when heat is imparted to a body its dimensions are immediately increased; and it is found that this increase takes place equally throughout every part of the dimensions, so that the figure or shape of the body is preserved, every part being enlarged in the same degree. Now, this effect must be produced by the constituent particles of the body moving to a greater distance asunder; and since the increase of diminution takes place equally throughout every part of the volume of the body, the component particles must be everywhere separated equally. In fact, they have driven each other to a greater distance asunder, and a repulsive force has consequently been called into action."*

Sir John Herschel, in his Treatise on Natural Philosophy, expresses himself thus, on the same subject :—

"The dilatation of bodies by heat forms the subject of that branch of science called pyrometry. There is no body but is capable of being penetrated by heat, though some with greater, others with less rapidity; and being so penetrated, all bodies (with a very few exceptions, and those depending on very peculiar circumstances), are dilated by it in bulk, though with a greater diversity in the amount of dilatation produced by the same degree of heat."

And, in continuation, he adds—

"But solids themselves, by the abstraction of heat, shrink in dimension, and at the same time become harder and more brittle, yielding less to pressure, and permitting less separation between their parts by tension. These facts, coupled with the greater compressibility of liquids, and the still greater of gases, strongly induce us to believe that it is heat, and heat alone, which holds the particles of all bodies at that distance from each other which is necessary to allow of compression; which in fact gives them their elasticity, and acts as the antagonistic force to their mutual attraction, which would otherwise draw them into actual contact, and retain them in a state of absolute immobility and impenetrability. Thus we learn to regard heat as one of the great maintaining powers of the universe, and to attach to all its laws and relations a degree of importance which may justly entitle them to the most assiduous enquiry."

In the "Connexion of the Sciences" it is stated to be

"A general law, that all bodies expand by heat and contract by cold. The expansive force of caloric has a constant tendency to overcome the attraction of cohesion, and to separate the constituent particles of solids and fluids; by this separation the attraction of aggregation is more and more weakened, till at last it is entirely overcome, or even changed into repulsion."†

"Whatever," says Mr. Donovan, "the nature of repulsion may be, it is found to be in some manner connected with what we call *heat*. Corpuscular repulsion is found to be increased by the presence of heat, and diminished by its absence. When heat increases the repulsion between the particles of a body, these particles must recede further from each other in all directions; and if they all take more remote stations, it is obvious that the bulk of the body must be increased: it is now, in fact, larger, although the quantity of matter remains the same, and it is said to be *expanded*."‡

* Heat, in the Cab. Cyclopædia. † Mrs. Somerville, p. 243.
‡ Chemistry, in Cab. Cyc. p. 40.

The attention will next be directed to a part of the *second* Theorem, namely, "*that the Earth is a non-luminous body, receiving its external light and heat from the sun;*" and, in continuation, to some of the evidences on which that assertion is founded.

Sir John Herschel, in his Treatise on Astronomy, says—

"Henceforward, then, in conformity with the above statements, and with the Copernican view of our system, we must learn to look upon the sun as the comparatively motionless centre about which the Earth performs an annual elliptic orbit of the dimensions and eccentricity, and with a velocity regulated acccording to the law above assigned; the sun occupying one of the foci of the ellipse, and from that station quietly disseminating on all sides its light and heat."

And again—

"The sun's rays are the ultimate source of almost every motion which takes place on the surface of the earth. By its heat are produced all winds, and those disturbances in the electric equilibrium of the atmosphere which give rise to the phenomena of terrestrial magnetism, &c. &c. . . . . The great mystery, however, is to conceive how so enormous a conflagration (if such it be) can be kept up. Every discovery in chemical science here leaves us completely at a loss, or, rather, seems to remove farther the prospect of probable explanation. If conjecture might be hazarded, we should look rather to the known possibility of an indefinite generation of heat by friction, or to its excitement by the electric discharge, than to any actual combustion of ponderable fuel, whether solid or gaseous, for the solar radiation."

In the article on heat in the Cabinet Cyclopædia, it is stated—

"From this it appears that the only external source of appreciable heat to the earth is the sun.

Sir Henry de la Beche, in his Manual of Geology, has the following sentence:—

"The superficial temperature of our planet is certainly very materially influenced by, if it may not be entirely due to, solar light and heat. That the difference of seasons and of the climates of various latitudes originates in the greater or less exposure to the sun is obvious. That local circumstances cause great variations of superficial temperature, is also well known; yet the principle seems to prevail that, under equal circumstances, the temperature decreases from the tropics to the poles."

In the "Connexion of the Sciences" it is said—

"The ocean of light and heat perpetually flowing from the sun must affect the bodies of the system very differently, on account of the varieties in their atmosphere, &c. . . . . . The direct light of the sun has been estimated to be equal to that of 5,563 wax candles of moderate size, supposed to be placed at the distance of one foot from the object."*

"One of the causes," says Professor Whewell, "which determines the temperature of each climate is the effect of the sun's rays on the solid mass of the earth. The laws of this operation have been recently made out with

* By Mrs. Somerville.

considerable exactness, experimentally, by Leslie, and theoretically by Fourier, and other enquirers. . . . . . .

"The earth, like all solid bodies, transmits into its interior the impressions of heat which it receives at the surface; and throws off the superfluous heat from its surface into the surrounding space. . . . . . . The parts of the earth near the equator are more heated by the sun than any other parts, &c. &c."*

And again, a little further on, he says—

"The next circumstance which we shall notice as indicative of design in the arrangement of the material portions of the solar system is the position of the sun, the source of light and heat in the centre of the system."†

I must, in continuation, recapitulate the first part of the *forty-seventh* Theorem:—"*That a comparison of the natural phenomena, in which the effects of light and heat are manifested, affords reason to infer the existence of a connexion so intimate between them as to warrant the belief of their identity.*"

Before proceeding to bring forward the *direct* evidences on which this Theorem is founded, reference is requested to the definitions given by Sir William Herschel, in a paper read before the Royal Society, May 15, 1800, of light and heat, whose manner of comportment in all essential circumstances are stated by him to be identical; and then let the only natural inference be drawn which can possibly be done by an unprejudiced mind, namely, *that no two substances or states of matter could comport themselves with such perfect similarity in such a variety of cases, and yet be essentially different.*

Sir John Herschel says—

"The laws of the radiation of heat have been studied with great attention, and have been found to present strong analogies with that of light in some points, and singular differences in others. Thus, the heat which accompanies the sun's rays, comports itself in all respects like light; being subject to similar laws of reflection, refraction, and even of polarization, as has been shown by Berard. Yet they are not identical with each other: Sir William Herschel having shown by decisive experiments, verified by those of Sir H. Englefield, that there exist in the solar beam both rays of heat which are not luminous, and rays of light which have no heating power."‡

"Between light and heat," says Dr. Ure, "so intimate a relationship subsists, that they must be conceived as two modifications of the same fundamental agency."

In another part of the same work he adds—

"Associated with light in the sun-beam, heat must also follow its theoretic fortunes."

In the Cabinet Cyclopædia it is said—

"That the principal properties of heat are so nearly identical with those of light, that the supposition that heat is obscure light is countenanced by strong probabilities."

* Bridgewater Treatise, pp. 76, 77. † Ibid, p. 169.
‡ Nat. Philos. in Cab. Cyc. p. 314.

Again—

"The calorific property which constantly accompanies the solar rays, as well as the rays proceeding from flame, would indicate that heat is a necessary concomitant or property of light. . . . . The whole body of natural phenomena in which the effect of heat and light are concerned, demonstrate an intimate physical connexion between these agents." And, "if the identity of light and heat be admitted, then the question of the nature of heat is removed to that of light."

"In what has just been said," says Professor Whewell, "we have spoken of light only with respect to its power of illuminating objects, and conveying the impressions of them to the eyes. It possesses, however, beyond all doubt, many other qualities. Light is intimately connected with heat, as we see in the case of the sun and of flame; yet it is clear that light and heat are not precisely identical. Light is evidently connected, too, with galvanism and electricity; and, perhaps, through these, with magnetism. . . . . . It manifests, also, chemical action in various ways."*

Mr. Turner bears the fullest testimony in favour of the point now sought to be established.

"From light," says he, "we cannot separate the recollection and companionship of heat. They are now found to be so generally existing in the latent or the active state wherever either is present, that they are thought to be modifications, or different conditions of the same element; when both these occur, we have fire. Fire is luminous heat, or heat in the state of light. The sun's light has the effect of both heat and light. . . . . The Hebrew word used by Moses, "*aor*," expresses both light and fire."†

In the "Connexion of the Sciences," the following corroborative testimony is given in favour of this point:—

"The progress of modern science, especially within the last five years, has been remarkable for a tendency to simplify the laws of nature, and to unite detached branches by general principles. In some cases identity has been proved where there appeared to be nothing in common, as in the electric and magnetic influences; in others, as that of light and heat, such analogies have been pointed out as to justify the expectation that they will ultimately be referred to the same agent; and in all there exists such a bond of union, that proficiency cannot be attained in any one without a knowledge of others." Again, ". . . . . Since the power of penetrating glass increases in proportion as the radiating caloric approaches the state of light, it seemed to indicate that the same principle takes the form of light or heat according to the modification it receives, and that the hot rays are only invisible light; and light, luminous caloric." Further, "The probability of light and heat being modifications of the same principle, is not diminished by the calorific rays being unseen, for the condition of visibility or invisibility may only depend on the construction of our eyes, and not upon the nature of the agent which produces these sensations in us. . . . .

"As the action of matter, in so many cases, is the same on the whole assemblage of rays, visible and invisible, which constitute a solar beam, it is more than propable that the obscure, as well as the luminous part, is

* Bridgewater Treatise, p. 138.

† Turner's Sacred History.

propagated by the undulations of an imponderable ether, and, consequently, comes under the same laws of analysis."

And, in conclusion from this writer—

"That light is visible heat seems highly probable; and although the evolution of light and heat during the passage of the electric fluid may be from the compression of the air, yet the development of electricity by heat, the influence of heat on magnetic bodies, and that of light on the vibrations of the compass, show an occult connexion between all these agents, which, probably, will one day be revealed. In the meantime it opens a noble field of experimental research to philosophers of the present, perhaps of future ages."*

We now require to examine the *forty-eighth* Theorem, and some of its accompanying evidences, namely, "*That by a concurring chain of deductive reasoning, drawn from the effects of the different heating powers of the component colours of the solar spectrum, when applied to substances reflecting various colours and degrees of heat; together with the corroborating testimony of the augmented heat of concentrated light, it is considered to be established beyond the possibility of doubt, that in these cases sunlight is the direct cause of heat.*"

"The calorific powers of the sun's rays," says the writer on heat in the Cabinet Cyclopædia, "may be exhibited in a very conspicuous manner by concentrating a large number of them into a small space, by means of a *burning glass*. . . . . . From experiments performed in this way by Count Rumford, it appears, however, that no change in the heating power of individual rays is produced by this means; but that the increased energy of their calorific action arises altogether from a great number of them being concentrated into a small space. . . . . . The heating power of the sun's rays, when collected by a burning glass, far exceeds the heat of a powerful furnace. A piece of gold placed in the focus of such a glass has not only been melted, but has been actually converted into vapour by Lavoisier."†

Sir David Brewster, in his Treatise on OPTICS, corroborates this opinion:—

"A combination of plane burning mirrors forms a powerful burning instrument; and it is highly probable that it was with such a combination that Archimedes destroyed the ships of Marsellas. . . . . . M. Peyrard conceives that with 590 glasses, about 20 inches in diameter, he could reduce a fleet to ashes at the distance of a quarter of a league; and with glasses of double that size at the distance of half a league. . . . . . The most celebrated concave mirrors used for burning were made by Mons. Villele, of Lyons, who executed five large ones. One of the best of them, which consisted of copper and tin, was very nearly four feet in diameter, and its focal length thirty-eight inches. It melted a piece of Pompey's pillar in fifty seconds, a silver sixpence in seven seconds and a half, a halfpenny in sixteen seconds, cast iron in the same time, slate in three seconds, and thin tile in four seconds."‡

There have thus been proved, by the concurring testimony of the

* Connexion of the Sciences. † Pages 349, 350.
‡ Optics, Cab. Cyc. p. 314.

most scientific writers of the age on the respective subjects under discussion, 1. That the sun is the source of the external light and heat received by the earth; 2. That light and heat are either identical or most intimately connected; 3. That the rays of sunlight cause heat; and 4. That heat causes expansion. It is requested that these several results may be carefully borne in mind, as they may be the means, hereafter, of enabling us to arrive at some important conclusions.

Let it now be seen what evidences there are for the support of the *fifty-first* Theorem, *That the phenomena arising from Attraction and those from Repulsion indicate the presence of two antagonistic forces acting at the same time on the particles of all bodies, and maintaining them in a state of equilibrium, which becomes more or less disturbed according as either of these forces preponderates.*

The Cabinet Cyclopædia remarks—

"We have seen that when heat is imparted to a body its dimensions have immediately increased; and it is found that this increase takes place equally through every part of the dimensions, so that the figure or shape of the body is preserved, every part being enlarged in the same degree. . . . . . In fact, they have driven each other to a greater distance asunder, and a repulsive force has, consequently, been called into action. On the other hand, if heat be abstracted from a body, its dimensions uniformly contract, its figure being preserved as before, and the diminution of size being equally produced throughout its whole volume. The component particles, in this case, therefore, approach each other equally throughout the whole volume of the body; in other words, they are drawn together, and an attractive force is brought into action. . . . . . These phenomena indicate the presence of two antagonistic forces, acting at the same time on the constitutional particles, and suspending them in equilibrium; namely, the *repulsive* agent, determined by the presence of heat, and increased in its energy by the increased application of the physical principle; and the *attractive* force, with which the particles are naturally condensed, and by which they always have a tendency to cohere in solid masses. So long as the energy of the cohesive principle exceeds the power of the repulsive force produced by heat, the body will remain in a solid state; but, by the continued application of heat, the energy of the repulsive principle being increased, and the particles continually separated, these two powers will at length be brought nearly to the state of equilibrium."

And again—

"If there were no external source of heat, the consequences would be that the earth, by constantly dismissing heat by radiation into the surrounding space, would be gradually cooled, and the temperature of all objects would fall indefinitely. Liquids would be converted into solids, and gases into liquids, and subsequently into solids."*

"All bodies," says another writer, "consist of an assemblage of material particles, held in equilibrio by a cohesive force which tends to unite them; and also by a repulsive force, probably caloric, the principle of heat which tends to separate them. The intensity of these forces decreases rapidly as

* Heat, in Cab. Cyc. pp. 8, 169, 177, et seq.

the distance between the particles augments, and becomes altogether insensible as soon as that distance has occupied a sensible magnitude. It is evident that the density of substances will depend upon the ratio which the opposing forces of cohesion and repulsion bear to one another."*

"We learn," according to Dr. Ure, "by scientific research, that each particular form depends on the relation between two opposite and contending powers—the attractive and repulsive. When the former power predominates, solidity prevails; when the latter, gasity, or the aerial state: and when the two, or nearly balanced, the liquid condition results.

"The attractive force is that which, under various modifications, gives origin to cohesion, tenacity, hardness, crystalization, and gravitation. Had *it* reigned alone in the terrestrial system everything would have been condensed into a motionless mass, in which water and air would have been fixed as the solid rock. This, therefore, is the natural condition into which the attractive particles of matter spontaneously tend to come, and at which they do arrive, unless counteracted by the divellent force called caloric or heat."†

And, lastly, on this subject, it is ascertained from Mr. Donovan,

"That it may be received as a general law, which, however, is not without exception, that the effect of cold on all bodies is to lessen their bulk, and to increase their specific gravity. Conversely, it might easily be anticipated, that, by adding heat, the repulsion of the material parts would be increased, the bulk would be augmented, and the specific gravity diminished; this, accordingly, is found by experiment to be the case; and the law applies to matter, whether in the solid, liquid, or gaseous state."‡

This, therefore, is another, and an important step in the direct progress of our argument. The conclusion was formerly come to that light and heat cause expansion. By this we perceive that the expansive influence occasioned by light and heat is the direct antagonist to attraction; for it is asserted, that "were this principle of expansion not present, mutual approximation, crystalization, solidification, in short attraction, would be the natural and infallible consequences." We also have been made aware that heat and light may be considered concomitants. Being so, and, at the same time, the cause of expansion, it follows that their absence would be equivalent to the absence of the expansive principle. But the absence of light is darkness, and, as has just been made out, the absence, also, of the expansive principle; while this, in turn, *is equal to the presence of the attractive principle.* Consequently, when this reasoning is applied to Scripture, it warrants the conclusion, that the words which state that "*darkness* was upon the face of the deep,"§ imply, as determinately, that "*attraction* was on the face of the deep."‖

* Connexion of the Sciences, by Mrs. Somerville, pp. 117, 243, et seq.

† Ure's Chemical Dictionary. ‡ Chemistry, Cab. Cyc. p. 44. § Gen. i. 2.

‖ Of this I have lately had a remarkable corroboration. On mentioning to a Hebrew philologist, during the course of conversation, the meaning I attach to the word "darkness," which occurs in this part of Scripture, and explaining how I arrived at that conclusion, he said that it had a peculiar signification which he could not very

In continuation, I have, if possible, to determine the true import of the expression in the original, which the translators have rendered "deep," and afterwards to enquire whether scientific writers concur in considering *attraction to extend throughout space, and to pervade all matter.*

With reference to the first of these points there are, fortunately, the following very apposite remarks in one of the Northern Reviews:—

"Of the earth (referring to the 2nd verse of Genesis), it is said that it was "*thohu,*" and "*bohu;*" of the "*thehom,*" that there was darkness on its aspect; and of the waters that they were subjected to the vital energy of the Spirit of God. Now the *thehom* here mentioned seems to be used in a wider sense than as an appellation of the deep sea, or the bottomless place; for it is separately distinguished from the waters. It probably has here a more primitive meaning than that which is implied in its etymological relation to *thohu,* namely, a boundless place, and is used to denote *space,* that which is boundless, not in *one,* but in all its dimensions, not the *deep,* but the *vast.*"*

This philological explanation appears closely to agree with the opinion of astronomers. Sir John F. Herschel, in referring to Newton's law of gravitation, says—

"Every particle of matter in the universe attracts every other particle with a force directly proportioned to the mass of the attracting particle, and inversely to the square of the distance between them."

And again—

"It is in consequence of the *mutual* gravitation of all the several parts of matter, which the Newtonian law supposes, that the earth and moon, while in the act of revolving, monthly, in their mutual orbits about their common centre of gravity, yet continue to circulate without parting company in a greater annual orbit round the sun."†

In the "Connexion of the Sciences" it is stated—

"The distance of the fixed stars is too great to admit of their exhibiting a sensible disc; but in all probability they are spherical, and must certainly be so if gravitation pervades all space, which it may be presumed to do, since Sir John Herschel has shown that it extends to the binary stars."‡

And in conclusion on this point, there is the forcible evidence of a recent writer, who, when describing the binary stars, says—

"One star moves round another (or, more properly, each round their common centre of gravity), in an elliptic curve; *precisely the curve which is described by the earth and other planets in their revolutions around the sun.*

closely interpret, but the nearest is *that where it was paramount nothing could progress,* from a *restraining* or *negative* influence which it was employed to signify; and cited, as an illustration, the word rendered "withheld," in the 2nd verse of the xxxth chapter of the same book, the word used in the original being the same as that in the 2nd verse of the 1st chapter, and with the intention of conveying precisely the same meaning.

* Presbyterian Review on Mr. Fairholme's Geology.

† Astronomy, Cab. Cyc. ‡ By Mrs. Somerville.

Uniformity of this sort is exceedingly remarkable; it points to *some common cause;* in other words, to the LAW OF GRAVITATION, which the nature of this curve enabled Newton to detect as the first principle of planetary order. Gravity has often been surmised to be universal: at all events we have now stretched it beyond the limits of the most eccentric comet into the distant intervals of space; whilst every extension of its known efficacy manifestly increases, in accelerating ratio, the probability that it is a fundamental law of matter."*

Thus carefully and enquiringly has this investigation been brought by two distinct routes to a converging point, where it is found that the *darkness* mentioned in Scripture, besides its more popular meaning as the *opposite of light,* has a scientific and more recondite signification, and one which leaves no doubt upon the mind that it was meant to imply *attraction,* or an influence which, were it permitted to operate exclusively, would so grasp all materialism as to reduce it into one solid motionless mass of inertia. And after having satisfactorily identified the *darkness* of Scripture with the *attraction* of science, the enquiry has been continued from sources connected with the latter, until it has been proved that *attraction* is an all-pervading principle, or, as Newton's followers express themselves, "the first principle of planetary order;" and equalled in ubiquity only by *light;* which may, therefore, with perfect propriety, be styled the *second* "principle of planetary order"—a result which the whole tenor of these enquiries respecting this subtile fluid, authorised the fullest anticipation.

* Architecture of the Heavens, pp. 92, 93.

SECTION IV.

INTRODUCTION OF THE LIGHT; THE CONSEQUENT PROTOROTATION OF THE EARTH; AND ITS DYNAMICAL RESULTS.

CHAPTER XIV.

Explanation as to the possibility of the Earth and other planets, with their respective satellites having, in accordance with astronomical laws, revolved in space around the common centre of the system, long previous to the illumination of the sun. Further proofs that Darkness implies Attraction. Consequence of this fact upon the development of our Theory. Existence of the primeval Light *before* it was divided from the Darkness, and the important bearing of this truth on the subject under discussion. A few concluding observations on the subjects treated of in this chapter.

HAVING reached this convenient resting place, it may be proper, on commencing another chapter, to avail myself of the juncture thus afforded, to say a few words in explanation of the position assumed from the first, on the faith of its being unquestioned, although at variance with most of our pre-conceived opinions. I allude to the fundamental doctrine of this Theory, that the earth, and other planets—in virtue of the same laws which now govern their orbital motions—revolved around the sun; the satellites around their primaries, and the whole around their common centre of gravity of the system, for *ages before the sun was illumined;* for it may be supposed, by those who have not enquired into these subjects, that the solar system could not have existed under such circumstances.

In a subsequent part of this work it will be satisfactorily shown that the planetary *orbital* motions in space, are perfectly independent of, and can exist with or without *rotatory* motion. Meanwhile, to convince the reader, that the solar system might exist, and perform all its orbital functions, although the sun should be again reduced to what it assuredly once was, for a long but indefinite period, AN OPAQUE MASS; and darkness should be again restored to its ancient dominion over the face of the deep—if the assertion made, to that effect, in Scripture be not deemed sufficient—the following opinions are offered, of men whose word should dispel all remaining doubts :—

"Let it be granted," says Professor Whewell, when deducing evidences of *design* from the sun being in the centre, "that the law of gravitation is established, and that we have a large mass, with others much smaller, in its comparative vicinity. The small bodies may then move round the larger, but this will do nothing towards making it a *sun* to them. Their motions might take place, the whole system remaining still utterly dark and cold, without either day or summer. In order that we may have something more than this blank and dead assemblage of moving clods, the machine must be lighted up and warmed.

"Now this lighting and warming by a central sun are something added to the mere mechanical arrangements of the universe. There is no apparent reason why the largest mass of gravitating matter should diffuse inexhaustible supplies of light and heat in all directions, while the other masses are merely passive, with respect to such influences. There is no obvious connexion between mass and luminousness, or temperature. No one, probably, will contend that the materials of our system are necessarily luminous or hot. . . . . .

"The sun might become, we will suppose, the centre of the motions of the planets by mere mechanical causes; but what caused the centre of their motions to be also the source of those vivifying influences? Allowing that no interposition was requisite to regulate the revolutions of the system, yet, observe what a peculiar arrangement in other respects was necessary, in order that these revolutions might produce days and seasons! The machine will move of itself, we may grant; but who constructed the machine so that its movements might answer the purposes of life? . . . . .

"This argument is urged with greater force by Newton himself. In his first letter to Bentley, he allows that matter might form itself into masses by the force of attraction. 'And thus,' he says, 'might the sun and fixed stars be formed, supposing the matter were of a lucid nature. But how the matter should divide itself into two sorts, one luminous, the other opaque, he confesses he knows not.'"*

There appears, therefore, to be nothing wanting to convince an unprejudiced mind, that *darkness* signifies *attraction;* and that according to the Mosaic account, it "was upon the face of the deep," implying space in all its vastness and extent; and consequently that it pervaded our system as a portion of space.

For my own part, I adopt these terms in the acceptation here given; and until they can be proved to have a different meaning they shall be applied accordingly in all future reasoning.

Yet, I desire not to be misunderstood; for no doubt there are minds capable of resisting this mode of reasoning; and, indeed, every mode of reasoning short of tangible evidences. For the convincing of such, it is to be regreted, that neither the nature of the subject, nor the present state of science, will admit of these *direct* appeals being made to their senses, although presently it will be shown *that during a long but indefinite period, there existed*

* Bridgewater Treatise, pp. 169—171. The remainder of this letter is not given, from being irrelevant to the present purpose, which is merely to prove, as is seen they both admit, *that the system could have existed though the sun had not been illumined.* —AUTHOR.

a state of matters on the face of our planet, to which light, as it now exists, so far from being serviceable, would actually have been inimical; and consequently could not, in accordance with the wisdom of the Creator, have possibly existed. Besides, by denying or refusing to accede to the supposition that *darkness* is the expression for *attraction,* it would imply, that the inspired historian has omitted to mention a principle which is known, and confessed to have pervaded the whole universe! A conclusion alike inconsistent with our belief in the wisdom and prescience of that Being who dictated the divine record, as well as with all experience regarding it; for no other circumstance, no, not even the most minute, is overlooked when such is necessary to render the announcement complete. But it is not alone in this part of Scripture that *darkness* is mentioned as equivalent to attraction. We have the authority of the Almighty himself, who when speaking from the whirlwind to his patient and afflicted servant, asks him in the sublime words which suited such an occasion, "Who shut up the sea with doors when it brake forth as if it had issued out of the womb? When I made the cloud the garment thereof, and *thick darkness* a swaddling-band for it."*

Taking, therefore, all these things into consideration, whether is it not more consistent with candour, or even with reason, to consider that the *darkness* alluded to is the expression for *attraction,* when such well-grounded evidence, both sacred and secular, can be adduced in favour of this reading? or, in the face of these proofs, and the concurring testimony of analogy, to persist in considering the words of inspiration to be defective?

The following considerations may, perhaps, serve to confirm the conviction with regard to the meaning here attached to the word "*darkness.*" Admitting, for a moment, that it does signify attraction—and we do not see how it can well be denied—then there is the following. *The ultimate end of attraction is rest or inertia;* for it cannot be conceived of matter tending, as it would do under the unrestrained influence of attraction, to a centre, without associating in the mind *the idea of its tending ultimately to rest.* But if attraction be *rest, inertia,* or *immovability,* then it follows that all *motion* must be the antagonist of attraction.

It certainly does not become finite, imperfect beings, to enquire too scrutinizingly into the nature of the movement which was communicated to "the waters;" all we have to do is to believe, *because it is so written,* that the counteracting influence to attraction, whose effects are still appreciable in the works of the Creator during the period when "darkness was upon the face of the deep," was communicated to matter by immediate and Divine influence; and that it was *motion* which was then communicated. Not only because it is thus recorded in Scripture, but because it is confirmed by reflection, and

* Job xxxviii. 8, 9.

the use of the reasoning faculties. For, as by the law of inertia, "matter can neither spontaneously create nor destroy motion in itself,"* consequently, whatever vibratory motion existed in the circumfluent, atmosphereless water of the earth *before* the formation of the light, must have been derived from a supernatural and immaterial source.

Those only who have felt the intense anxiety of mind arising from the contemplation of such subjects—which require to be traced out in the illimitable field in which they exist, and the fear which is entertained in doing so, of blending or weakening truth by conjecture—are capable of appreciating the comfort of finding spots of such secure foundation as those which have just been elicited, and which, springing from opposite sources, science and religion, afford a firm footing amid all that is obscure and dubious around.

Science has rendered incalculable service by tracing so clearly the boundary line of the capability of matter, and by frankly declaring "that it is unable to engender spontaneous motion in itself, or to destroy it when once it is originated by any external cause." Whilst, with an assurance such as this, exhibiting the inherent limits of matter, it is satisfactory to be informed by the Creator himself that he supplied that which was wanting; and what matter could not do for itself was done for it by Divine power.

These investigations, likewise, seem to strengthen the reliance which the mind is disposed to place in the truthfulness of this recondite portion of Scripture. For, it may be remembered, that considerable pains were taken to draw a broad line of distinction between the two consecutive creative acts; that of *forming the light complete in itself*, and that of *impressing a peculiar state or condition upon it*. The former of these was considered to have permeated all materialism with an ethereal quiescent fluid. The latter communicated to that elastic, tenuous expansion, a vibratory movement of almost inconceivable rapidity, and in a direction which should cause it to act as the antagonist of attraction. And it is when we distinguish most clearly *between* the perfection of the constitutional nature of this all-pervading fluid and its impressed condition, and also keep before the mind that, at the period alluded to in the second verse of Genesis, it was *not* in existence, that we shall be most fully impressed with a conviction of the correctness and truth of the announcement therein made. All matter is *now* pervaded with the ethereal fluid to which such frequent allusion has been made, and through its movements or vibrations light and heat are communicated, by certain determinate laws, to the former. "In the beginning," however, the whole material universe was surrounded by aqueous envelopes; this as regards the *Earth*, has been made clearly manifest in the three preceding sections, when showing what were the existences, alike of the animal and vegetable kingdoms, which

* Vide the sixty-seventh Theorem.

then tenanted the bottom of the primitive water; and also that the stratified rocky masses were deposited from an ubiquous ocean which held their elements in suspension; and, consequently, that the whole sphere was circumbounded by water. Indeed there is every reason for supposing that *then* there was no existent state of matter of greater tenuity than *water*. To this, therefore, the requisite vibratory motion was communicated by the only Being who could impart it, or who could determine the degree of warmth necessary to maintain it, and the material portion beneath, in the state best adapted for sustaining and fostering the myriads of living creatures and of plants which were destined to dwell beneath, and there to work out his sovereign will and pleasure.

The great difference between the medium which received and communicated the sensation of heat in that era of the earth's history, and the ethereal medium which now performs the same office, may, possibly, account for the additional density which, in general, is found, by the exuviæ, to have prevailed in the external coverings of zoophyta, plants, and apulmonic animals of the ancient world; and to which reference has been made in the *hundred and thirty-seventh* Theorem. To this, however, I shall merely allude, leaving it to others, and to a more advanced condition of science, to elucidate the subject more thoroughly; but, even now, it may be beneficial to caution whoever engages in this new and ample field of investigation, to beware of confounding in any degree the *power* and the *free will* of God with the *designs* which it pleased him then to have in view. It was not the *want* of power which withheld the light from existing as now constituted for so many ages, but because another, and a more direct agency was more consonant with the plan of creation. Neither was the arm of the Omnipotent less capable of having "stretched out the firmament like a curtain" from everlasting; but because he chose to place the whole material universe in vacuo, and in that state to cause his multifarious organic instruments to produce that which would endure. Not air dissolving textures, but hard, stony, perdurable substances, which should remain, and, by layer after layer, encrust the mundane sphere, in preparation for the first rotation of the earth, when they should start into life, as it were, and form themselves into continental chains and oceanic hollows, with all the variety of hill and dale, mountain and valley, which render the present earth so fitting an abode for those creatures destined in due time to be ushered in for the purpose of rendering him intellectual service, and for his own glory.

I shall, therefore, with this advertency, leave the conception, that the peculiarity in the external *media*, which the animals and plants of the non-rotating period were made to interpose between themselves and the communicating medium of heat during that era, has an intimate connexion originating from a law common to both, to be matured by others; but, in the meantime, it may be observed,

that what has been made out so clearly respecting the working of the Creator "in the beginning," has opened up a fine vista into those remote periods of time, by showing us, that although "darkness was upon the face of the deep," yet there has been an undeviating unity of plan from the first; that during the whole period shadowed forth by "the beginning," the law of progression, by repeated consecutive acts of creative energy, was the principal feature impressed upon matter. That it was, in fact, the development of the great plan of creation, traced from everlasting, and continued to be unfolded until the riches of a wisdom which is unsearchable was fully displayed, and it could be declared that the whole was "very good."

The following passages from some of the scientific writers of the day, seem to corroborate the views here adopted of LIGHT and DARKNESS; while they more especially tend to confirm the idea of the identity of DARKNESS and ATTRACTION:—

"The luminous *ether*, then," says Professor Whewell, "if we so call the medium in which light is propagated, must possess many other properties besides these mechanical ones on which the illuminating power depends. It must not be merely like a fluid poured into the vacant spaces and interstices of the material world, and exercising no action on objects; it must affect the physical, chemical, and vital powers of what it touches. It must be a great and active agent in the work of the universe, as well as an active reporter of what is done by other agents. It must possess a number of complex and refined contrivances and adjustments which we cannot analyse, bearing upon plants and chemical compounds, and the imponderable agents; as well as those laws which we conceive that we have analysed, by which it is the vehicle of illumination and vision. . . . . . All analogy leads us to suppose, that if we knew as much of the constitution of the luminiferous ether as we know of the constitution of the atmosphere, we should find it a machine as complex and artificial, as skilfully and admirably constructed.

"The mere fact, however, that there is such an *ether*, and that it has properties related to other agents in the way we have suggested, is well calculated to extend our views of the structure of the universe, and of the resources, if we may so speak, of the power by which it was arranged. The solid and fluid of the earth are the most obvious to our senses; over this, and in its cavities, is poured an invariable fluid, the air, by which warmth and life are diffused and fostered, and by which men communicate with men; over and through this again, and reaching, so far as we know, to the utmost bounds of the universe, is spread another most subtile and attenuated fluid, which, by the play of another set of agents, aids the energies of nature, and which, filling all parts of space, is a means of communication with other planets, and other systems."*

"It appears highly probable," says Professor Buckland, "from recent discoveries, that light is not a material substance, but only an effect of undulations of *ether;* that this infinitely subtile and elastic ether, *pervades* all space, and even the interior of all bodies; SO LONG AS IT REMAINS AT REST

* Bridgewater Treatise, pp. 138—140.

THERE IS TOTAL DARKNESS; WHEN IT IS PUT INTO A PECULIAR STATE OF VIBRATION, THE SENSATION OF LIGHT IS PRODUCED: this vibration may be excited by various causes; *e. g.* by the sun, by the stars, by electricity, combustion, &c. If, then, light be not a substance, but only a series of vibrations of ether, *i. e.*, an effect produced on a subtile fluid by the excitement of one, or many extraneous causes, it can be hardly said, nor is it said in Gen. i. 3, to have been *created*, though it may be literally said to be called into action."*

In a previous part of this section it was endeavoured to be proved that, in Scriptural language, *darkness* signifies *attraction*, and that attraction propends by its inherent nature to *immobility*, *inertia*, or *rest*. Now, in the passage just quoted, Dr. Buckland, supported by numerous respectable authorities, considers darkness to be "*the ethereal medium at rest.*"

The conclusion that such might have been the case, nay, even that for a brief period it *actually was* the case, had been reached by a different route, and without being aware of the concurrence of this learned writer in its favour. But it must be remembered, that this "state of rest of the ethereal medium," which is called light in Scripture, was comparatively of *mere momentary duration*. Its *formation* and its being *put into motion* having been two consecutive acts of creative energy performed *on the same day*. Whilst the evidence, in this instance, of Dr. Buckland and others, goes to prove, that the *existence* of the ethereal medium, and its *movement* are *separate* and *distinct*, and that the one may exist altogether irrespective of the other, which is tantamount to the admission that the motion which it did receive was communicated to it by some power or influence exterior to and above itself.

The other attendant opinion entertained in this theory, viz., that during the period of non-rotation, or that which is signified by "the beginning," the "ethereal medium" did not exist in its perfected condition, is entirely a distinct conception, and rests alone upon the authority of Scripture; for, with every reliance on this, it is believed that at the time when it is said "darkness was on the face of the deep," it is not meant to imply, that this all-pervading element was then stretched out, although it had not been put into motion, *in the perfect sense of that term*, but that *as yet there was no ethereal medium at all*, although the materials of the ethereal fluid were created during the period called the beginning, in common with the materials of everything else pertaining to our system. But its existence *then*, in its perfect state, was not in accordance with the degree of development which the plans of the Creator had, at that period, undergone. But whenever these were sufficiently matured, it was immediately put into vivid motion and requisition; and became the active instrument of completing many of the subsequent works of that eventful week.

It would indeed have been alike consistent with truth, whether

* Bridgewater Treatise, vol. i. p. 32.

the words of the original had been rendered into our language, "*attraction* was on the face of the deep," or "*darkness* was on the face of the deep:" while it is considered that the movement mentioned in the clause immediately following, did impart, in due proportion, the counteracting principle (that is, to *attraction*) according as the progressive state of the creation then required, or could receive it. The *light*, as it is now constituted, and the effects which its formation produced, would have been positively injurious to the operations *then progressively taking place towards a state of perfection and fixity, which renders the light, as we now enjoy it, necessary for its permanency and well-being.*

It is scarcely possible to conceive that while the creation was passing through innumerable stages of progression, never stationary at any one point in the scale, nor indeed could be until it was finished, and pronounced to be "good," light upon fixed and permanent principles, whereby a certain quantity only is imparted daily,* should have been, at all, adapted to it. *A progressive state, with a constant determinate fostering medium, is not, cannot be considered consistent with the wisdom of the Creator.* This self-obvious truth being conceded, it follows that the spirit of him who was forming and preparing the whole *for a subsequent state of permanency*, which it was to attain at a future period, could alone have supplied the proper and requisite portions of warmth, or heat, or motion, or counteracting principle to gravitation, during all the successive stages of its progression. For who could have known or divined the particular point to which the whole was tending—to which all the conjoint means were to concentrate in perfection, except the Spirit of the Creator himself?

This conclusion is assuredly the legitimate result of the attendant conditions, *whenever a progressive state of the Creation is admitted.* We must either believe that, in a state of progression, the supply of heat would be varied, or doubt that the sun now yields a fixed and determinate quantity of that enlivening and all-pervading medium. But this latter point being established, it enables us to come to the final conclusion, that, whatever may be thought respecting the ethereal medium of modern philosophy, this is known—and, fortunately, it is sufficient for our future purpose—that the "*darkness*" of Scripture does mean "*attraction,*" and that the movement mentioned there also communicated that proportion of the countervailing principle which was most conducive to the well-being of creation, as it passed through the successive stages of progression, until it reached its present perfection. These truths having been sufficiently established to admit of their being applied throughout the remainder of this treatise, will enable me to adduce evidences of a more tangible, and purely geological description, to contribute in establishing the fact of the NON-ROTATION of the

* See the 2nd Theorem.

EARTH, in corroboration of what has all along been so earnestly contended for.

The part which has been gone through of this branch of the general evidences may be considered as purely intellectual, having had exclusively to do with abstract principles and mental symbols; and may, with propriety, be compared to that period of Columbus's undertaking when he found himself under the necessity of explaining those correct, but abstract conclusions which so clearly revealed to his mind—but to his alone—the existence of the Western World. The section about to be entered upon may, not inaptly, be compared to the labours of that discoverer when engaged in proving the soundness of his conclusions by the choicest of all tests, their application to practice. It may be that this expedition through a hitherto unexplored region, has, like his, been beset with difficulties of so disheartening a character to those who, in every respect, are not like minded, or so high in hope as myself, that they may wish to turn back, longing for the safe and care-free haven from whence they set out.

But should there be any such, I would reanimate and encourage them by our determination on the one hand, that whether they part company with our little bark in mid-passage or not, it is designed to prosecute the adventurous voyage; and by the assurance, on the other, that if they will be of good cheer for a little longer, while passing through these shoreless regions of thought, they will experience the satisfaction of being landed in safety on the *terra firma* of geological proof, as evident, tangible, and solid, as are the objects with which that science usually is conversant.

SECTION IV.

INTRODUCTION OF THE LIGHT; THE CONSEQUENT PROTOROTATION OF THE EARTH; AND ITS DYNAMICAL RESULTS.

CHAPTER XV.

Some of the immediate effects of the Light with reference to its dynamical power. During the first three days it was not concentrated around the Sun, consequently different from the light at present received. The expansive influence of Light and Heat act in opposition to Attraction. The repulsive power of Light investigated and established. The introduction of Light into the material universe equal to the introduction of a new *force*. Laws of force and motion investigated with reference to this event. Expansion being a *force*, and the bodies of the solar system being incapable of expanding beyond their prescribed orbits, they must have expended or met this new force by *rotation around their respective axis*—show that the Earth has a double movement in space, and that the diurnal rotation is perfectly independent of the periodical revolution around the Sun. Other corroborations of these important conclusions. Sunlight the residue of the primary light. Evidences to prove the enormous amount of Heat and Light which come from the Sun, and the application of this to our general argument.

In prosecution of what was resolved upon at the close of the last chapter, I shall endeavour, in continuation, to estimate the consequences which resulted to the earth by the introduction of the Light into the material universe, when the plan of creation was so far matured as to admit of—indeed to require this new agent—in order to put the earth in motion; for without the sudden impetus of the primary light our planet would have continued to have slumbered on, unknown to rotatory motion, around the unillumined sun, enveloped in its stony crust of horizontal concentric strata, surmounted by an atmosphereless ocean, but entirely without any inequalities of surface.

Before proceeding, however, to trace the momentous consequences which sprang from the introduction of the light, it may be conducive to the development of this theory to consider, that it was the introduction of a *new force* into the material universe which was, at the period, indispensable to promote the plan of Creation, and that only by conferring on Light a nature totally distinct from attraction could this required power be instituted.

To appreciate fully, therefore, the importance of the announcement, that "*the light was divided from the darkness*," we must recur to what was endeavoured to be substantiated at the commencement of this section, namely, that *darkness* is the expression for *attraction;* and then learn from Sir John Herschel, the *direction* of that centripetal force.

"The direction of attraction," that gentlemen says, "at every point of the orbit of each planet *always passes through the sun.* No matter from what ultimate cause the power which is called gravitation originates, be it a virtue lodged in the sun as its receptacle, or be it a pressure from without, or the resultant of many pressures or solicitations of unknown fluids, magnetic or electric ethers, or impulses: still when finally brought under our contemplation, and summed up into a single resultant energy, its *direction* is, from every point on all sides towards the sun's centre."*

By combining these truths with the one under consideration, there results, that to "divide the light from the darkness," signifies, to impress upon it an opposite nature or tendency to that of darkness. But *darkness* is *attraction;* and, therefore, if attraction be a force propending *towards* or propelling matter *towards* the centre, light or heat must be a force propelling matter *from* the centre—a conclusion which perfectly accords with what has already been said, viz., that light and heat are so intimately connected, as to warrant the assumption of their identity;† that heat causes expansion;‡ that expansion is the antagonist of attraction;§ and, therefore, as before stated, if *attraction* acts in a direction from the circumference towards, and through, the centre, then *expansion*, as its antagonist, must act in a contrary direction, or towards the circumference.

In corroboration of the justness of the view here adopted, I have to offer, that which equally applies to a similar, though subsequent, announcement, wherein it is said that "the water *under* the firmament was *divided* from the water *above* the firmament." This, as will be clearly shown in its proper place, signifies, that the water *above* the firmament was caused to ascend in the atmosphere by being combined with the expansive principle, while that which was *under* the firmament, being less saturated with that principle, descends, to unite itself with the mass of water preserving its original state of liquidity; and thus, a perfect division is effected between these two states or conditions of water, in consequence of the one being impressed with a tendency to *ascend*, while the other takes a *contrary* direction, from a point which, for wise purposes, is itself variable. In like manner, it is conceived, that the division effected of the *Light* from the *Darkness*, implies a *divergency of motion:* for as motion is one of the most important conditions of matter, or means of producing change or modification in the material universe,

* Astronomy, in Cab. Cyc. p. 221, et seq.
† 47th Theorem.
‡ 50th Theorem.
§ 51st Theorem.

too much care cannot be bestowed in investigating narrowly the primitive laws which impressed a permanency of character upon it; while, perhaps, no agent wielded during that period by the Omnipotent was ever more available or more universally employed than LIGHT, the second general law of materialism; and which then, for the first time, was introduced, in its *appreciable* material state, into the works of the Creator; from whom it received the impulse of motion so often alluded to, and which it could not, from being material, have generated in itself—thus affording another testimony of the intimate knowledge of the laws of matter, communicated to the inspired writer, by him who alike dictated those remarkable announcements, and called the light into existence.

Assured, therefore, that during the first three days of the Mosaic week, the light, although it existed, was *not* concentrated around the sun; that consequently it was *not, could not,* be the description of light which is now received from that luminary;—convinced, that wherever it was during that intervening period, it was precisely where the plans of the Creator required that it should be; and satisfied that the important positions which have been successively taken up and proven, namely, its ubiquity; its perfection *before* it was put into motion; and that when put into motion it was impressed with a nature which made it the opponent of gravity—that these are sufficient to permit the argument being proceeded with; I shall endeavour, next, to determine the probable consequences of the introduction of the expansive principle of light into the material universe as it was then constituted; confining the investigation to those which would take place on our planet, revolving, without rotatory motion, round an *un*illumined sun, and constituted geologically, as at the conclusion of the last and commencement of the present chapters, it has been supposed to have been.

This investigation will be commenced by recapitulating the *sixty-eighth* Theorem:—"*That the molecules of bodies are not placed together merely in unrelated juxtaposition, but either cohere and resist separation, or mutually repel each other; while the mutual approach, by attraction of particles placed at a distance from each other, or their further separation by repulsion, are effects of the same class, both of which are termed* FORCE. *That, therefore, 'whatever produces or opposes the production of motion or pressure in matter is force;' in which sense it is the name or symbol for the unknown cause of a known effect. That* FORCE, *when manifested by the mutual approach or cohesion of bodies, is called* ATTRACTION; *separable into as many branches as it has distinct modes of displaying itself. But when* FORCE *is indicated by the re-motion of bodies from each other it is called repulsion or expansion.*"

Convinced by this, that repulsion is one of the two principal forces recognized, by mechanical writers, as governing materialism, the next process will be to examine some of the evidences regarding its intensity:—

"It is a general law," observes Mrs. Somerville, "that all bodies expand by heat and contract by cold. The expansive force of caloric has a constant tendency to overcome the attraction of cohesion, and to separate the constituent particles of solids and fluids; by this separation the attraction of aggregation is more and more weakened, till, at last, it is entirely overcome, or even changed into repulsion. . . . . . By the continual addition of caloric, solids may be made to pass into liquids, and from liquids to the aeriform state, the dilatation increasing with the temperature; and every substance expands according to a law of its own."*

"The first and most common effect of heat," according to the Cabinet Cyclopædia, "is to increase the size of the body to which it is imparted. This effect is called dilatation or expansion; and the body so affected is said to expand, or be dilated. If heat be abstracted from a body, the contrary effect is produced, and the body contracts. These effects are produced in different degrees, and estimated by different methods, according as the bodies which suffer them are solids, liquids, or airs."†

"Caloric," says Dr. Ure, "is the agent to which the phenomena of heat and combustion are ascribed. This is hypothetically regarded as a fluid of inappreciable tenuity, whose particles are endowed with indefinite idio-repulsive powers, and which, by their distribution in various proportions among the particles of ponderable matter, modify cohesive attraction, giving birth to the three general forms of gaseous, liquid, and solid. . . . . The force with which solids and liquids expand or contract by heat and cold is so prodigiously great as to overcome the strongest obstacles."‡

These evidences will suffice to convince any one of the enormous, the almost irresistible, power of *expansion*. This being in direct proportion to the *quantum* of light and heat, there will next have to be investigated the consequences of the introduction of so inconceivable an amount of the expansive influence into this system, the remainder of which, in its visible condition, is now concentrated around the sun; and in attempting this, it is fortunately not necessary for the present, to take into account either its primitive locality or direction, *but merely its expanding influence*. This requires us to enter upon what may be considered the test of those principles which, from the commencement, have been laid down; and it is now, therefore, that they must be relied upon as the fundamental ones of this theory. If they have the validity which they are considered to possess, they will carry us through. With this assurance, let us continue our discourse.

The first idea which occurs to the mind, is, that by the formation of the light, and its division from the darkness, a new agent, a new cause, a new FORCE, was introduced into the system; and this, in reality was the case. Every cause being accompanied by a corresponding effect, and the definition of "force" being "whatever produces, or opposes the production of motion in matter;"§ we must endeavour to discover the legitimate effects, or the motion engen-

* Connexion of the Sciences, p. 234.
† Heat, in Cab. Cyc. p. 8.
‡ Chemical Dictionary, pp. 253, 257.
§ Mechanics, Cab. Cyc. p. 7.

dered, by this new *force* thus introduced to such an amazing extent; assured, beforehand, that as it did not *oppose* the production of motion, it must necessarily have *caused* it. Instead, however, of making the enquiry general to the whole of the solar system, it will be restricted to the phenomena experienced by our own planet; being persuaded, that results similar to those which took place on this, would be common to all the other spheres of the solar economy. Before proceeding farther, it may be well to reiterate the following fundamental positions, namely, that although the earth, during its period of non-rotation, circulated in free space around the sun, under the dominion of the same laws which at present govern its orbital course in the heavens; yet, according to that of gravitation, so long as the earth consisted of the same *quantity* of matter, it *could not increase, in the smallest degree, its mean distance from the sun.** Consequently, as there has been neither any augmentation nor diminution of the mass of matter of which it is composed, ever since it was translated in space, at the beginning, although its materials are now differently combined in the relative positions of their molecules, it must be concluded that *it neither did, nor could at any time, for any cause, nor under any circumstances, deviate in the slightest possible degree, from its original orbit;* or, in the language of astronomers—"whatever may have been the form of the ellipse, or successive ellipses, which it has described around the sun, the length of the longer axis of the orbit has continued to be invariable," a truth which it will be found particularly useful to bear in mind, while the following investigations respecting the laws of force and motion are gone into.

The first to which reference will be made is a part of the *fifty-second* Theorem, which states, "*That an irresistible body of analogies leads to the conviction, that the same physical properties, which observation and experience disclose in the smaller masses immediately surrounding us, are possessed by the infinite systems of bodies which fill the immensity of space. That the distribution of heat is regulated by the same laws amongst the bodies of the universe as amongst those which exist on our globe.*"

At the risk of being considered tiresomely prolix, I must, for the sake of perspicuity—the chief desideratum in close reasoning—call to mind what has already been brought so prominently forward, namely, the creation of the ethereal fluid, or the light, of the first three days; its ubiquity, both as to extension and minuteness; the circumstance of its having been made and completed before it was put in motion; its having been subsequently put in motion; and that the motion then given, conferred a state or condition upon it which caused it to become the opponent of attraction. And having these particulars present in the mind, it is next to be considered, that as the "distribution of heat" is regulated by the same laws among

* Connexion of the Sciences, p. 408. Likewise the 70th Theorem.

the bodies of the universe, as among the bodies which surround us, "and the greater masses of the universe, including the earth itself, are playing, though on a greater scale, the self-same part as do the most minute particles of dust which dance in the sunbeam, or the still more impalpable atoms of air which float around us;" while the introduction of heat amongst these indivisible molecules of matter, of whose movements we have a more intimate knowledge, from being immediately under our observation, invariably causes them to *expand* or *separate* from each other. We are warranted, according to what has been announced in the *fifty-second* Theorem, to conclude, that similar consequences would result, should a proportionate quantity of heat be introduced amongst *the larger indivisible molecules* of the universe. Now, the spheres of the various systems constitute those larger molecules of the universe; and if, in place of contemplating them in general, the attention be restricted to those only of the solar system, and suppose that what are called molecules should assume the more appropriate name of planets, there may assuredly be extended to them the same conditions, especially when it is considered that the light was infused almost ubiquously into materialism, and *afterwards* put into motion with a vividity beyond conception, and from these combined reasons finally conclude *that, could they possibly have increased their distance from each other, the introduction of the* LIGHT *would, in like manner, have produced a corresponding expansion, in the regions of space, among the spheres of our system.*

It has just been shown, however, that owing to certain peculiarities in the law of gravitation, unless a proportional augmentation had simultaneously been made to the respective masses of the planets, they could not deviate in the smallest degree from the orbits in which they commenced to circulate when first translated in space, which is equivalent to saying, that *they could not possibly expand.* While all previous reasoning and the evidences brought forward have, alike, conspired to prove, that no ponderable element was added to the earth during the protracted period of non-rotation. On the contrary, that this seems to have been sedulously avoided, and the work of deposition and solidification carried on solely by the combined agency of chemical and electrical influences, and of animal and vegetable vitality. Consequently, unless it can be satisfactorily proved, that on the formation of the light, they did receive some increment to their respective masses, *other consequences must be searched for than those of expansion amongst the spheres of the system, as the result of the introduction of this new force;* which, being known not to have *opposed* motion, *must,* as the remaining condition of the problem, *have produced it in some direction or other.*

Under this view of the case, and in order to ensure the most thorough conviction, it requires only to be proved, that no augmentation of ponderable matter was made to the earth by the formation

of the light. There being minds so reluctant to admit any new conception, that rather than believe what has been stated, they would endeavour to persuade themselves, that the earth and other planets received such an increase to their respective masses by the impartation of light, as would enable these orbs, in virtue of the proportional law of gravitation, to expand in space, or separate from each other and from the sun; and thereby continue to describe orbits round that central luminary, although of greater circuit than formerly. Fortunately, however, for the cause of truth, the imponderable nature of light has occupied the attention of philosophers of all countries, and been made the theme of protracted discussion; and is now universally admitted to be as stated in the *forty-sixth* Theorem, namely, "*That light and heat either do not possess the property of gravitation, or possess it in so small a degree as to be wholly inappreciable by any known means of measuring it;*" while the several authorities which support that opinion, and are subjoined to the Theorem can be consulted, should any doubts still lurk in the mind as to the soundness of the assertion, and a hope be raised of having discovered an outlet for the expenditure of the newly-introduced force now alluded to. But, on the contrary, the unprejudiced adoption of what has been said, and a deliberate perusal of the accompanying evidences, will show the fallacy of such an expectation. There is, therefore, no alternative left, but that of proceeding in earnest to look for some more probable manner of accounting for the expenditure of this new force—a force of such amazing power—which was thus introduced into the material universe, by the formation of the light, and its division from the darkness.

Meanwhile, the following passage is so apposite with respect to the *levity* of light and heat, that I give it with much pleasure :—

"The question, whether the increase of magnitude caused by raising the temperature of a body arises from its having received any addition of a *material* substance to its mass can only be decided by previously fixing on some one quality which will be regarded as inseparable from matter, and, therefore, the presence or absence of which being ascertained, will decide the presence or absence of the additional portion of matter under enquiry. The quality which seems best adapted for such a test is weight; and the question, whether the increased dimension of a heated body proceeds from its having received any excess of ponderable matter becomes one which is to be decided by direct experiment. Experiments to ascertain this fact have been instituted, attended by every circumstance which could contribute to ensure accurate results, but no change of weight has been observed. We are, therefore, entitled to conclude, that whatever be the nature of the principle which gives increased dimensions to a body, when its temperature is raised; whatever it be which fills the increased interstitial spaces from which its constituent particles are expelled, it is not a ponderous substance —it is not one on which the earth exerts any attraction—it is not one which if unsupported would fall, or if supported would produce any pressure on that which sustains it."*

* Hydrostatics, in Cab. Cyc. pp. 142, 143.

Let us now, therefore, commence this straightforward endeavour, by recapitulating the nature of the forces which maintain the earth, and other bodies of our system, in the respective orbits which they describe around each other. The first part of the *fourth* Theorem bears directly on this point—"*That the orbital revolutions of the* EARTH *and other planets around the sun, almost in the plane of its equator, and of the satellites around their primaries, are caused by the combination of the sun and the planets' mutual attraction, and an original projectile impulse.*" This will enable us to perceive, that the earth is maintained in its orbit by two nicely equipoised forces, whose conjoint result causes its orbital revolution: and likewise that those two forces produce one uniform and constant motion, merely from their being so justly proportioned to each other as not to admit of increase or of diminution in either;* or, in other words, *they are incapable of resisting any additional pressure which might be brought to bear upon them; for any such would infallibly be destructive of the resultant motion.* It is requested that these facts may be kept present to the mind, as allusion will frequently be made to them during the reasoning which follows.

Having established these preliminary points, let us now see what is stated in the *seventy-fifth* Theorem—"*That forces, in general, are classed according to the duration of their action into* INSTANTANEOUS *and* CONTINUED; *the effect of the former being produced in an infinitely short time. If the body which sustains it be previously quiescent and free, it will move with a uniform velocity in the direction of the impressed force; but if the body be so restrained that the impulse cannot put it into motion, then the fixed points or lines which resist the motion will receive a corresponding shock, called percussion, at the moment of the impulse; and which, like the force that caused it, is instantaneous. A continued force will produce a continued effect, with corresponding results.*"

Now, the formation of the light, and its division from the darkness, was, to the spheres of the solar system, revolving round each other in darkness, equivalent to the application of an expansive force amongst them, whose effects they must either have *resisted*, *expended*, or *receded* from. But these celestial bodies, we have just learnt, were from the beginning, and still continue to be, maintained in their respective orbits, by two divellent forces, in just and delicate equipoise; consequently, they were incapable of either deviating from their assigned orbits, and, by expanding in space, thus to retreat from it; or of continuing to revolve in their orbital paths had they been made to resist the newly-applied force: and this, too, whether its direction was from the centre of the system towards the circumference; from the circumference towards the sun; or from any point intermediate between these directions; for, in either of

* The constancy here alluded to is altogether irrespective of the secular mutations in the form of the elliptic orbits occasioned by the disturbing influence of the other bodies of the system.

these cases, a pressure equal to the applied force would require to have been either *borne* or *retreated* from; while, as has just been demonstrated, they could neither *resist* any additional pressure on their orbital motion, nor *recede* before it. Consequently, it may safely be concluded, *that in neither of these ways was the newly-formed expansive force either resisted, receded from, or expended.*

I shall now recur to the first part of the *seventy-sixth* Theorem, namely, "*That if a point on which a force be applied is free to move in a certain direction not coinciding with the applied force, it will be resolved into two elements, one of which will be in the direction in which the point is free to move, and the other at right angles to that direction. The point will move in obedience to the former element, and the latter will produce percussion or pressure on the point or line which restrains the body.*"

An attentive perusal of those parts of the "Treatise on Mechanics" which contributed to the formation of this *Theorem* will show, that when a force is applied to any body free to move in a direction not coinciding with that of the applied force, the force itself will be resolved into two elements, *one of which will produce percussion or pressure on the points or lines which restrain the body.*

But, having been made aware that neither the earth nor any of the planets, in consequence of the nice adjustment of the powers which maintain them in their respective orbits, *could resist any degree of pressure whatever,* we must also abandon any hope which may have been entertained, that in this way the application of the force introduced into the solar system, by the formation of the Light and its division from the Darkness, can be satisfactorily accounted for.

This leads to the consideration of what is stated in the *seventy-seventh* Theorem—"*That if a solid body, moveable on a fixed axis and susceptible of no motion, except one of rotation on that axis, be submitted to the action of instantaneous force, one or other of the following effects must ensue :—*

1*st. The axis may resist the force and prevent any motion.*

2*nd. The axis may modify the effect of the force, sustaining itself a corresponding percussion; and the body will receive a motion of rotation; or*

3*rd. The force applied may be such as would cause the body to revolve round the axis, even were it not fixed; in which case the body will receive a motion of rotation, but the axis will suffer no percussion.*

And that the same results proceed from the application of continued forces."

Applying the truths contained in this Theorem to the case under consideration, it becomes obvious, from what has been already stated, that the *first* of these conditions could not possibly have taken place. *The earth's axis could not have resisted the force and prevented the motion.* For the same reasons neither could the *second* consequence have followed the application of the force in question, for the earth's

axis could not "*have modified the effect of the force and have sustained a corresponding percussion.*"

And, therefore, as neither of these two conditions of the Theorem could have taken place, we are constrained to admit the remaining one, and to conclude

That the consequences of the expansive force introduced into the material universe by the formation of the light and its division from the darkness, when applied to the non-rotating spherical earth, was, to cause it to revolve around its axis in such a manner that the axis suffered neither pressure nor percussion.

This could only have been accomplished by the new force having acted in such a manner, that its power was exerted in a tangential direction, thereby causing no pressure on the axis of the body which was impressed with rotatory motion.

The soundness of this final conclusion is corroborated in a remarkable manner, by the speciality with which the announcement having reference to it is worded; for be it observed, the rotation of the earth is there treated of, not as a *primary* law, but as an *effect;* and an *effect* produced by the operation of a law *directly* mentioned, with others which, from only being implied, must have been known to have previously existed.

For, after making the announcement alluded to, the narrative goes on to state, "The evening and the morning were the first day;" an *indirect* method of informing us, without expressly stating it, *that the earth at this time performed its first rotation;* for without diurnal motion, there could have been neither morning nor evening, day nor night. And it is again to be remembered, that the words of this chapter of Genesis *were the laws which constituted Nature itself.* All that is present to our perceptions, and we, ourselves, existing merely in virtue of these laws, and others of similar potency, which, although not specifically mentioned, *are as clearly implied;* therefore it is essential to distinguish when a law is directly announced, and when it is only implied by the mention of its effects; for in this latter case, a law causing any effect, either wholly or in part not directly recorded in this chapter, *must have previously existed,* as it co-operated to produce that which is expressly narrated. The truth of this observation is forcibly exemplified in the case we are now contemplating; while the observation itself is akin to, and perfectly accordant with the fundamental principles laid down at the commencement of this work.

It has been aptly observed by a recent writer, "that Sir William Herschel soon came to the conclusion that gravitation, although it accounts for the proximity of bodies, does not alone account for the *stability* of systems; there must also be orbital motion;"* in like manner, it is here considered, that though rotatory motion is to be attributed to the effects of the expansive principle of light introduced into

* Nichol's Architecture of the Heavens, p. 75.

the universe; nevertheless, the formation of the light, and even its division from the darkness, although this conferred upon the former properties diametrically opposed to attraction, could not of itself have caused the rotation of the earth around its axis, *unless it had been previously counterpoised in space by two nicely-balanced powers, which left it free to revolve, while they enabled it to do so as around a fixed axis.* At the same time, by a dexterous application of these principles to the verses just quoted, in which no mention is made of such pre-existing laws; while the formation of the light and its division from the darkness, although not sufficient of themselves to have caused the change contemplated, are announced to be *the completion of what was required to cause the revolution of the earth around its axis*, another great truth is clearly brought out, namely, that both *centripetal* and *centrifugal* force must have existed from "the beginning." By this it can be explained how the earth and other planets could have revolved around the sun, and the whole round the common centre of gravity, although the central orb was not, as now, illumined. Otherwise, it is impossible to conceive a system composed of various spheres, some revolving round others, partly by the influence of attraction, unless they had been impressed with centrifugal impetus; or, on the other hand, to imagine one sphere revolving round another, or rather around their common centre of gravity, without the existence of attraction, as an antagonist to the centrifugal force thereby generated. Hence, if it can be proved, that the whole of the stratified masses constituting the greater part of the earth's rocky crust, were formed during the period *when as yet the earth was not impressed with diurnal rotatory motion*, it must follow, as a necessary consequence, that the duration of its non-rotatory revolution around the *unillumined* sun, or of "the beginning," was that required for the deposition and formation of those masses.

In order to show that the earth actually performs a double revolution in space, and thereby relieve the mind from any doubt that may arise from the suspicion, that the motion of diurnal rotation is either necessarily or in any manner dependent on orbital motion, the following truths contained in the *third* Theorem are referred to —"*That the* EARTH *has a double movement in space; one by which it revolves around its own axis in* 24 *hours solar time, or in* 23 *hours* 56′ 4.09″ *sidereal time, and another movement whereby it performs its periodical revolution in an invariable plane around the sun in what is termed the tropical year of* 365 *days* 5 *hours* 48′ 49″·7. *That these two motions are entirely independent of each other. And that if the Earth did receive its double movement from a single impulse, it is considered by computation that the impulse must have passed through a point about twenty-five miles from its centre.*"

As a corroboration there is subjoined what is said in the *Connexion of the Sciences*, regarding the independency of these two movements:—

"If a sphere at rest in space receive an impulse passing through its centre of gravity, all its parts will move with an equal velocity in a straight line; but if the impulse does not pass through the centre of gravity, its particles having unequal velocities will have a rotatory or revolving motion at the same time that it is translated in space. These motions are independent of one another; so that a contrary impulse passing through its centre of gravity will impede its progress without interfering with its rotation. As the sun rotates about an axis, it seems probable if an impulse in a contrary direction has not been given to its centre of gravity, that it moves in space accompanied by all those bodies which compose the solar system; a circumstance which would in no way interfere with their relative motions; for, in consequence of the principle that force is proportional to velocity, the reciprocal attractions of a system remain the same, whether its centre of gravity be at rest or moving uniformly in space. It is computed that, had the earth received its motion from a single impulse, that impulse must have passed through a point about twenty-five miles from its centre.

"Since the motions of rotation and translation of the planets are independent of each other, though probably communicated by the same impulse, they form separate subjects of investigation."*

"The planets," says the author of the *Architecture of the Heavens*, "move around the sun in orbits almost in the plane of the sun's equator, and in the direction of the sun's rotation on his axis; they rotate on their axes in the same direction, and—with some exception as to Uranus—the whole satellites revolve around their primaries also in that direction, nor are the rotations of these secondary bodies, in as far as they are known, subject to a different law. Now, these phenomena receive no explanation from what we usually term the law of gravitation, *inasmuch as gravitation could sustain systems distinguished by no such conditions. Nay, it actually does so*, for the comets are free from all these laws; they move in very eccentric orbits inclined to the plane of the sun's equator at all degrees, and their motions are as often retrogade as direct."†

Depending chiefly on geological phenomena, which may be termed the *practical* or *tangible* evidences, I shall not bring forward any further theoretical proof in support of the present position, considering what has been already said sufficient to convince any unprejudiced mind, as far as mere theory can effect that purpose. But should any one still doubt that the formation of the light and its division from the darkness caused the earth and other spheres to revolve around their axes, we would merely ask them *What then did it do?* It must have done something. The light *must* have had

* Mrs. Somerville's Connexion of the Sciences, 3rd edition, pp. 9, 10. Should the views I have adopted of the non-rotation of the earth for ages, and of its diurnal motion having been communicated by the formation of the light, be eventually confirmed, astronomers may perhaps be induced to change their conceptions of the *supposed direction* of the impulse which translated it in space. In lieu of being considered, as it now is, to have passed through a point about 25 miles from the earth's centre, it will de found to have passed through the centre of gravity of the spherical non-rotating earth, or tangential to the direction of the sun's attractive influence, which would infer its having arisen from a force *identical in kind with that of expansion*.—Author.

† Nichol, 1837, pp. 176, 177.

an *effect;* for there is no cause, however trivial, without an effect; indeed, it cannot be a *cause* without having an *effect;* and, consequently, it is to be supposed that this, one of the most stupendous of known causes, must have been attended by an effect of corresponding magnitude. I repeat, therefore, the enquiry, If the first effect of the introduction of the light and its division from the darkness was not that of causing the spheres to revolve, what was it? And again, if the earth and other orbs revolved around their respective axes from the "beginning," how was the *new force*—the introduction of Light into the material universe—*expended* or disposed of?

These may appear remarkable questions; but it should be remembered that I am strangely circumstanced, my true position towards the earth's inhabitants being this, that while there is, perhaps, not a single person capable of reflection who for an instant doubts that the earth now revolves around its axis, there is, perhaps, not another being on its surface, at the present moment, who believes, THAT THERE WERE AGES WHEN, ALTHOUGH IT REVOLVED AROUND THE SUN AS IT NOW DOES, IT HAD NO DIURNAL MOTION. It therefore becomes me to strengthen my argument by all possible means; and with this design, before closing the present chapter, some allusions will be made to a subject which hitherto has been deferred.

In consequence of not considering the Light, *as now received from the sun,* to have been in any manner instrumental in having caused the sun itself, the earth, and the other spheres of the system to rotate around their respective axes, there has not, hitherto, been brought forward any evidence to show the intense heat which the sun is considered to engender. Nevertheless, as the primary light and the light of the sun are mere modifications of each other, in a manner analogous to the blaze of light which bursts forth, when the charcoal-tipped wires of the voltaic pile are brought into contact by a skilful electrician, after having, by their *invisible* streams, caused rotation, decomposition, and many other surprising experiments, and the spectators are thereby made to appreciate in a more convincing manner the potency of the unseen element which he had before put into activity, and employed in performing those experiments; so the light and heat which now issue from the solar orb may be assumed as an appreciable measure of comparison in any endeavour which may be made to form an estimate of the intensity and power of that stream of *primary unseen* light, which caused the rotation of the spheres of our system, and of every system where rotatory motion is known to exist, which decomposed the water, and formed the atmosphere, which evaporated the surplus vapour; gathered the water together and left the dry land in possession of stores of their saline associates for the future use of man, animals, and plants; and whose unwearied potency was made to combine in a few hours all the woody textures and fibres of the phanogamous vegetable kingdom; and was afterwards, by the all-powerful hand of

the Creator, made to collapse until the stream of invisible light came into contact with that of darkness—whose centre had always been in the sun—or, in other words, until the streams of *expansion* and *attraction* met around the central orb of our system,* and, at the command of the Omnipotent, have ever since sent forth those regulated supplies of warmth and light which sustain all nature; the conjunctive force or intensity of which has drawn the attention of some of the ablest of our modern philosophers, and whose deductions shall be given in a few brief extracts; expressing, previously, the conviction that as the rays of light emitted from the charcoal point are merely the visible manifestation of the union of two streams, whose well-springs are in the voltaic generator behind; so the luminary which enlivens all nature is solely the junction-point of those streams of *attraction* and *expansion* whose fountain is inexhaustible and everlasting.

The following are the philosophical opinions above alluded to, and which, of course, are restricted to what is alone visible: —

"The ocean of light and heat," observes Mrs. Somerville, "perpetually flowing from the sun, must affect the bodies of the system very differently, on account of the varieties in their atmospheres, some of which appear to be very extensive and dense. According to the observations of Schroetz, the atmosphere of Ceres is more than 688 miles high, and that of Pallas has an elevation of 465 miles. These must refract the light, and prevent the radiation of heat like our own. . . . . .

The direct light of the sun has been estimated to be equal to that of 5,563 wax candles of moderate size, supposed to be placed at the distance of one foot from the object. That of the moon is probably only equal to the light of one candle at the distance of twelve feet. Consequently, the light of the sun is more than *three hundred thousand times greater* than that of the moon."*

"That the temperature at the visible surface of the sun," says Sir John Herschel, "cannot be otherwise than very elevated—much more so than any artificial heat produced in our furnaces or by chemical or galvanic processes—we have indications of several distinct kinds. First: from the law of decrease of radiant heat and light, which, being inversely as the squares of the distances, it follows that the heat received on a given area exposed at the distance of the earth, and on an equal area at the visible surface of the sun, must be in the proportion of the area of the sky occupied by the sun's apparent disc to the whole hemisphere, or as 1 to about 300,000. A far less intensity of solar radiation collected in the focus of a burning-glass suffices to dissipate gold and platina in vapour. Secondly: from the facility with which the caloric rays of the sun traverse glass, a property which is found to belong to the heat of artificial fires, in the direct proportion of their intensity. Thirdly: from the fact that the most vivid flames disappear, and the most intensely ignited solids appear only as black spots on the disc of the sun, when held between it and the eye. . . . . . . The sun's rays are the ultimate source of almost every motion which takes place

* Sun, the centre of attraction.—Connexion of the Sciences, p. 7.
† Connexion of the Sciences, pp. 253, 254.

on the surface of the earth. By its heat are produced all winds, and those disturbances in the electric equilibrium of the atmosphere which give rise to the phenomena of terrestrial magnetism. By their vivifying action vegetables are elaborated from inorganic matter, and become, in their turn, the support of animals and of man, and the sources of those great deposits of dynamical efficiency which are laid up for human use in our coal strata. By them the water of the sea is made to circulate in vapour through the air, and irrigate the land, producing springs and rivers. By them are produced all disturbances of the chemical equilibrium of the elements of nature which, by a series of compositions and decompositions, give rise to new products, and originate a transfer of materials.

"The great mystery, however, is to conceive how so enormous a conflagration (if such it be) can be kept up. Every discovery in chemical science here leaves us completely at a loss, or, rather, seems to remove farther the prospect of probable explanation. If conjecture might be hazarded, we should look rather to the known possibility of an indefinite generation of heat by friction, or to its excitement by the electric discharge, than to any actual combustion of ponderable fuel, whether solid or gaseous, for the origin of the solar radiation."*

* Astronomy, in Cab. Cyc. American edition, pp. 200—202.

SECTION IV.

INTRODUCTION OF THE LIGHT; THE CONSEQUENT PROTOROTATION OF THE EARTH; AND ITS DYNAMICAL RESULTS.

CHAPTER XVI.

Geological Phenomena in proof of the Earth's period of Non-rotation, divided into *external* and *internal* evidences, the former consisting of abstract mechanical laws applied to geological manifestations. Centrifugal impetus, engendered by rotation, the admitted cause of the equatorial protuberance of the Earth, and of the oblate form of other planets of our system. Geographical data in corroboration of the former assumption. *Internal* or geological evidences to the same effect. Origin of Continental Ridges and of Oceanic Hollows. Mechanical-dynamic Laws brought forward to account for the elevation of the horizontal concentric strata of the non-rotating sphere. Their change of position, and the vast extension of surface occasioned by the spherical earth having been suddenly transformed into a spheroid of rotation.

Having, in the preceding chapter, presented a vivid idea of the potency of the primary light, by inference, from that of the sun, in order, if possible, that no essential point should be left undetermined; I shall now proceed to another chain of reasoning entirely distinct from the former, and having for its general object, to explain the manner in which it is considered that the geological phenomena can be made to prove the non-rotatory period of the earth's existence. And, while, as a whole, it is offered as a body of evidence having tangible materials for its basis; yet, for greater perspicuity, it requires to be divided into two branches: one, whose superstructure is founded on well-known and established, but *abstract principles* of mechanics; and another—the most important—arising from *material* geological phenomena, which can be seen, weighed, and handled; and which, consequently, carry perfect conviction to the mind—that conviction generally attendant on the evidence of the senses.

I shall commence, as a part of the former division of these proofs, with what is contained in the *seventy-second* Theorem. "*That when a body has a motion of rotation, the line round which it revolves is called an axis; in which case every point in the body must move in a circle whose centre lies in the axis, and whose radius is the distance of the point from it. That, sometimes, when the body revolves, the axis, itself, is moveable, and, not unfrequently, in a state of actual motion; the motions of the earth and planets being examples of this kind.*"

Having thus shown that writers on mechanical laws recognise the

earth as one of those "bodies" revolving round an axis, in which every point moves in a circle, whose centre lies in the axis, and "whose radius is the distance of the point from the axis," I shall next endeavour to trace, *theoretically*, the consequences which proceed from it. In doing this, let reference be made to the first portion of the *seventy-third* Theorem, in which it is clearly stated, "*That the same causes which produce pressure on a body when restrained, will produce motion if the body be free. Accordingly, if a body be moved by any efficient cause, it will, by reason of the* CENTRIFUGAL FORCE, FLY OFF; and *the moving force with which it will thus retreat from the centre round which it revolves will be the measure of the centrifugal force.*"

If, with a knowledge of this upon the mind, we proceed, without losing any time, to the perusal of the *seventy-fourth* Theorem, it will be perceived, at once, what writers on mechanics and astronomy consider to have been the more general results of the revolution of the earth around its axis. Observing, however, that *they* conceive the rotatory motion to have been impressed upon it by the same impulse which caused its orbital revolution, but which, although at variance with the fundamental principles of this theory, does not affect the validity of the evidence as far as it goes. In the Theorem alluded to, it is stated, "*That to the centrifugal force arising from the rotation of the earth around its axis, and to its greater opposition to gravity in the equatorial regions, is attributed the protuberance of its form in those regions; or the excess of the equatorial beyond the polar diameter. And that this opinion is corroborated by the excessive oblate form, and corresponding rotatory velocity of Jupiter.*"

As this is rather an interesting point, precaution will be taken to examine some of its evidences in detail, before going on to consider the actual results with more detention.

"The most remarkable and important manifestation of centrifugal force" —says the writer on Mechanics, in the Cabinet Cyclopædia—"is observed in the effects produced by the rotation of the earth upon its axis. This rotation causes the matter which composes the mass of the earth to revolve in circles round the different points of the axis as centres, at the various distances at which the component parts of this mass are placed. As they all revolve with the same angular velocity, they will be affected by centrifugal forces, which will be greater or less in proportion as their distances from the centre are greater or less: consequently, the parts of the earth which are situated about the equator will be more strongly affected by centrifugal force than those about the poles. The effect of this difference has been, that the component matter about the equator has actually been driven farther from the centre than that about the poles, so that the figure of the earth has swelled out at the sides, and appears proportionately depressed at the top and bottom, resembling the shape of an orange. The exact proportion of the polar to the equatorial radius has never yet been certainly ascertained. Some observations make the equatorial radius exceed the polar radius by 1-277th, and others by 1-335th. The latter, however, seems the more probable. It may be considered to be included between these limits.

"The same cause operates more powerfully in other planets which revolve more rapidly on their axes. Jupiter and Saturn have forms which are considerably more elliptical. . . . . . . But there is another reason why the centrifugal force is more efficient in the opposition which it gives to gravity near the equator than near the poles. This force does not act from the centre of the earth, but is directed from the earth's axis. It is, therefore, not directly opposed to gravity, except on the equator itself. On leaving the equator, and proceeding towards the poles, it is less and less opposed to gravity."*

"The forms of the planets"—it is stated in the "Connexion of the Sciences"—"result from the reciprocal attraction of their component particles. A detached fluid mass, if at rest, would assume the form of a sphere, from the reciprocal attraction of its particles. But if the mass revolve around an axis, it becomes flattened about the poles and bulges at the equator, in consequence of the centrifugal force arising from the velocity of rotation, for the centrifugal force diminishes the gravity of the particles at the equator, and equilibrium can only exist where these two forces are balanced by an increase of gravity. Therefore, as the attractive force is the same on all particles at equal distances from the centre of a sphere, the equatorial particles would recede from the centre, till their increase in number balance the centrifugal force by their attraction. Consequently, the sphere would become an oblate, or flattened spheroid; and a fluid partially or entirely covering a solid, as the ocean and atmosphere cover the earth, must assume that form in order to remain in equilibrio. The surface of the sea is therefore spheroidal, and the surface of the earth only deviates from that figure where it rises above, or sinks below the sea. But the deviation is so small, that it is unimportant when compared with the magnitude of the earth; for the mighty chain of the Andes, and the yet more lofty Himalaya, bear about the same proportion to the earth that a grain of sand does to a globe three feet in diameter. Such is the form of the earth and planets. The compression or flattening at their poles, is, however, so small, that even Jupiter, whose rotation is the most rapid, and, therefore, the most elliptical of the planets, may, for ordinary purposes, from his great distance, be regarded as spherical."†

These quotations are very satisfactory and conclusive generally so far as they go, but as there is occasion for considerable exactitude in the present enquiry, I must proceed in quest of such investigations as shall determine the precise amount of the centrifugal force, in order to be convinced, that the rotundity of the earth's equatorial diameter accords with deductions made by *a priori* calculations. With this design let us resort to the *first* Theorem, in which it is stated—"*That the* EARTH *is a spheroid of rotation, whose equatorial exceeds its polar diameter about twenty-six miles, the former being* 7,925, *the latter* 7,899 *miles. That the oblateness of this ellipsoid, deduced from actual measurement, although somewhat less than mathematicians affirm it should be, from calculations based on its dimensions, time of rotation, component materials, law of gravity, and centrifugal force, nevertheless corresponds as nearly as the data for calculation will admit.*"

* Mechanics, in Cab. Cyc. pp. 105, 106.
† Connexion of the Sciences, 3rd edition, pp. 8, 9.

And any, or all, of the numerous authors on whose accredited writings that elementary theorem is founded, may be consulted, should more particular information be required, or any doubt remain on the mind.

Meanwhile, explaining that the dimensions above given are taken from Sir Henry de la Beche's "Manual of Geology," I shall consider it sufficient to adduce one concurrent quotation from Sir John Herschel's "Treatise on Astronomy," in which he refers to an "Essay on the Figure of the Earth," by Professor Airy. It is as follows:—

"Without troubling the reader with the investigation, which may be found in any part of the conic sections, it will be sufficient to state, that the lengths which agree, on the whole, best with the entire series of meridianal arcs which have been satisfactorily measured on the earth's surface, are as follow:—

	FEET.	MILES.
Greater equatorial diameter	41,847,426	7,925,648
Lesser, or polar diameter	41,707,620	7,899,170
Difference of diameters, or polar compression	139,806	26,478

The proportion of the diameters is very nearly that of 298,299, and their difference 1-299th of the greater, or a very little greater than 1-300th."*

After perusing these evidences, it is presumed that no doubt can be entertained as to the CAUSE of the protuberance in the equatorial regions of the earth. This will be admitted by all who reflect upon the subject, but perhaps few or none consider its oblateness to have taken place *after* it had circulated, as a sphere, for ages round an unillumined sun; and subsequent to the stratified rocks having been deposited from its primitive ocean, in successive concentric hollow spheres, above the unstratified masses, then also in a similarly horizontal position. Or, in other words, the actual rotation of the earth, and the equatorial protuberance occasioned by it, are readily admitted by all; *but the epoch of the commencement of the one, and the origin of the other, have hitherto been considered to coincide with that in which it was translated in space.*†

Whatever has hitherto been cited in this Theory, to ascertain the precise figure of the earth, and to adduce consequences from it, may

* Treatise on Astronomy, p. 114.

† It is not my intention to delay the general argument, by fully opening up the interesting field for expatiation which presents itself, when we endeavour to grasp the consequences resulting from the establishment of the fact, that *the diurnal rotation of the Earth took place at a distinct and distant period from that of its orbital motion in space.*

The mind, freed from the trammel under which it has so long laboured in this respect, is at liberty to attribute boldly the *orbital* movements to a force *similar in kind* (because proceeding from the same source, though infinitely vaster and more comprehensive), which, by its tangential influence, caused the whole orbs of the universe to revolve around their respective centres of gravity, the axis of their orbital path. To this I can only allude at present; perhaps I may enter upon it more fully hereafter.—AUTHOR.

be considered as a part merely of its *external* evidences; having been *derived from abstract truths*, founded on abstruse calculations, and profound mathematical manipulations; but the evidences now about to be brought forward—based exclusively on geological phenomena—may, with perfect propriety, be termed its *internal* evidences, undeniable proofs, written in legible characters, within the reach of all who choose to dedicate a few hours of exhilirating exercise to their perusal; and by examination, to assure themselves of the truth of their existence by the strongest of all convictions—ocular demonstration.

At this, as the most opportune juncture, I would observe, that while it was indispensable for the disciples of Copernicus to have recourse to objects *beyond* the earth, to prove that it has *orbital* and *diurnal* motion; and by means of these distant and distinct objects to overcome the inveterate prejudices of *apparent ocular* conviction to the contrary, confirmed by the imperceptible uniformity of motion in all the parts of the moving mass on which those who doubted were, at the very moment, unconsciously whirled through space—with me it is almost the reverse. The *actual* rotation of the earth is now so well established, and is an element so intimately bound up with the conceptions of every living being, that *to assert it ever was otherwise* will be found as incredible as was the announcement of *orbital* motion by Copernicus; while I am, in consequence, constrained to *adopt an entirely distinct line of proof. External* bodies, except in one or two respects, will be of little avail. The earth's rotation finds little sympathy at such remote distances, or, to express this more correctly, the respective rotations of the spheres exercise but little mutual influence on each other; it will be of little avail to go to them for proofs; these must be almost exclusively drawn from the symptoms of *change within the compass of the earth itself*, and more especially upon its surface—its geological manifestations, and the formation of its continental ridges and oceanic depressions.

But to return to the subject more immediately under notice: let the attention be directed for a moment to the following considerations:—In consequence of the diurnal rotation of the earth being considered to have been impressed upon it by the same impulse which caused its translation in space, it has, hitherto, been looked upon, as a natural result, that the earthy parts should have assumed their present form of equilibrium, while yet capable of doing so, by being in a fluid state either from aqueous, or from igneous liquifaction. Even those who, being most bold, have departed farthest from these conceptions of fluidity, and of coeval movements in space, have only ventured to conjecture, that although it was formed at first, as a sphere, it might gradually have acquired its present relative dimensions, and have become a spheroid of rotation, from the united agency of comminution, disintegration, and the equilibrizing

effects of its aqueous portion; but without having explained how the water, which must previously have assumed the form of rotation, or of rest, came afterwards to exercise those equilibrizing effects on materials of greater density than itself.

Setting this important omission, however, entirely aside for the present, it may be observed in general, that none seem yet to have dealt in earnest with the difficulty; or have endeavoured to account, in an intelligible manner, for the position of the strata with relation to each other; or with respect to the primary masses; or for the formation of the great continental ridges and oceanic hollows; nor indeed for innumerable other natural appearances. These, when touched upon at all, are treated at respectful distances, or hurried over in general terms, as points not requiring, or which, perhaps, can ill bear discussion, although their importance demands that they should not by any means be overlooked in a theory of the world. In short, they have hitherto been difficult points in all geological disquisitions, which even the most profound thinkers have been glad to dispose of in a transient manner; and, consequently, when introduced, have left no impression of correctness on the minds of the readers; or, rather, have left them entirely in doubt.

It is hoped, therefore, that it may be considered an additional pledge for the truth of the present Theory, when it is known, that however careful to avoid misleading any one, *it is intended to dwell particularly on those very points, and to bring them forth as the firmest and surest conclusions;* trusting to prove, that to this very change in the form of the earth, from a sphere to a spheroid, *effected in the short space of twenty-four natural hours*, are to be traced all those geological and geographical phenomena which have hitherto baffled explanation. I beg, however, it may not be overlooked, that while thus anticipating the true and only explanation of the cause of that motion, and the effects proceeding from it, little or no progress could have been made without the surprising and well attested facts brought to light, and established by the intelligence and industry of geologists, naturalists, and other scientific men; and, therefore, standing as a day's-man between those who place implicit faith in Scripture, while they turn aside from the lights of philosophy; and those—in a more critical position—who, while they gaze with delight on the dazzling lustre of philosophic lore, wilfully shut their eyes to the softer and more glorious light of Revelation; I would be understood as saying to the one: "While you gladly and joyfully listen to the inspired Word, be not insensible to the majesty of the works, which are wrought in truth, and are fearfully and wonderfully made." To the other it might be said: "Amidst the excitement and the exhilarating influences, caused by the investigations of the works of the Creator, oh! turn not a deaf ear to his word. Remember that nature cannot answer *all* your enlightened and intelligent ques-

tions; but in order that you should be fully informed of the origin of her stores, you must turn at last to Nature's God; and to what he has been pleased to reveal in his sacred volume regarding them."

Let not, therefore, believers in the Bible any longer dread the announcements of nature's wonders; they were all framed and fashioned by their Lord's own hand; nor let the votaries of nature's phenomena any longer deride the worshippers of his word; for without *it* they can neither satisfactorily account for that of which they are in quest, nor return without it to the right path from whence they have so long diverged; but rather, let harmony reign between them; for only by their cordial reconciliation and perfect union, can the truth be effectually established.

But to proceed with the argument. Let that be conceived to have been, which in reality was the case, namely: *That the spherical non-rotating earth, geologically constituted as it is described in the preceding section, and performing its periodical revolution around the unillumined sun, by the conjoint influence of two divellent forces, so nicely equipoised as to be incapable of resisting the slightest addition to either, was, by the application of an instantaneous tangential force, made to revolve around its axis, with an angular velocity of* 15° *per hour, and then let an endeavour be made to determine the results.*

To enable us to do this there will, first, be demonstrated what is contained in part of the *seventy-eighth* Theorem: "*That when a solid body revolves on its axis all its parts are whirled round together, and each performs a complete revolution in the same time; consequently, the angular velocity is the same for all. The tendency of each particle to fly from the axis, arising from the centrifugal force, is resisted by the cohesion of the parts of the mass, and, in general, the tendency is expended in exciting a pressure or strain upon the axis, whose amount depends upon the figure and density of the body and the velocity of its motion.*"

According, therefore, to the tenor of this Theorem, it is evident, that when the earth was caused to revolve, the consequences mentioned in it would take place, either by the cohesion of the parts resisting the inclination to fly off, which was occasioned by the centrifugal force being brought to bear upon them, and the general tendency be expended by exciting a pressure or strain upon the axis; or, the cohesion amongst the particles would be too weak to resist the force engendered by the centrifugal impetus, and they would, therefore, hasten to assume such an arrangement among themselves, as should confer on the whole mass the form of equilibrium under rotation, and so relieve the axis from the strain or pressure indicated above. In effecting which change of arrangement, they would be subjected to all those results proceeding from movement among the various parts of which the whole mass is constituted. Now, the previous investigations have made us aware, not only that the earth's axis could *not* have resisted the consequent

strain or pressure to which it would—according to the former alternative—have been subjected, but likewise, that both by calculation and actual measurement it has been ascertained, *that the centrifugal force overcame the cohesion among the parts of the earth's outer crust, and both caused and enabled it to assume the oblate form best adapted to meet the rotatory motion with which it was impressed, and thereby to relieve the axis from all strain upon it.*

In the immediate sequel it will be satisfactorily proved that this change was effected *after* all the stratified masses preceding the upper portion of the coal measures had been deposited, and therefore it follows, as a natural consequence of these combined truths, *that in accommodating themselves to the alteration in the earth's form, which has just been indicated, from a sphere to a spheroid of rotation, the strata, and other mineral masses, must have undergone very considerable changes in their relative positions.*

To be thoroughly convinced of this, in a general way, as also of the fact, that there must have been an instantaneous intrusion of *unstratified* rock amongst the *strata;* let the following consideration be duly appreciated, namely, a spheroid, the mean of whose diameter is 7,912 miles, has upwards of *eight hundred and sixty-one thousand square miles* more of superfice than a sphere whose diameter is 7,899 miles;* and those being the dimensions corresponding to the earth as it now is, and as it was before rotation, it follows—that in order to complete the outer crust of a world, on which such an immense increase of surface had been instantaneously produced, there required to have been provided as instantaneous an amount of solid rock to fill up the expansion which had thus taken place. Nor must it be supposed, that this difference of surface is the estimate at its full extent; for, were the inequalities occasioned by the continents and ocean beds, the mountains and valleys, and other flexuosities of surface, taken into account—the above being merely deduced from plane surfaces—the actual increase would be found to be infinitely beyond that which has been stated.

It must, at once, be confessed, that the superficial extent of rock, instantaneously required to fill up this void, could not have been supplied from any resources residing in *the stratified masses themselves.* For there is no possible way, according to natural cause and effect, whereby a movement of the earth could have occasioned a spreading out of the strata over this enormous increase of surface; and, likewise, over that which has not been taken into account.

It is said, "according to natural cause and effect," because, for wise purposes, the rotation of the earth around its axis, was ordained to be the *natural* effect of causes instituted directly by the Deity, with power to produce, in sequence, that stupendous result as their first and chief effect; therefore, it is considered quite justifiable to adopt

* It is to be remembered that I do not consider that the solids of the earth became flattened in polar diameter *after* rotation.

this language, without in the least attempting to limit the infinite powers of the Creator; but, on the contrary, while reverencing those attributes of Omnipotence, I look upon myself as authorised, in the present instance, according to the natural connexion between cause and effect, to conclude, that not only was there no possible way whereby the strata could have been made to cover this extra surface, but the vertical positions, which most of them have assumed, would increase the embarrassment, was it attempted to bring them forward as sufficient for the exigency contemplated; it being well known, and readily admitted, that a plane of any given dimensions, covers a greater concentric surface when horizontal, than when tilted up into any angle whatever out of perfect horizontality; some other phenomena must therefore be looked to for a satisfactory explanation of this difficulty; although it will lead us into rather a lengthened chain of reasoning, requiring the aid of various Theorems and their accompanying evidences; and the combination of truths, which, perhaps, have never before been brought into juxtaposition; nevertheless the undertaking must be continued with patient perseverance, in hopes that it may ultimately lead to satisfactory results.

SECTION IV.

INTRODUCTION OF THE LIGHT; THE CONSEQUENT PROTOROTATION OF THE EARTH; AND ITS DYNAMICAL RESULTS.

CHAPTER XVII.

Geological evidences required for the application of the dynamical influences of protorotation. Relative thinness of the earth's crust when compared with its semidiameter. The existence of this "outer shell" of the earth established. Relative densities of the materials composing the amorphous and the stratified formations of which it consists. Concluding deduction from these investigations—that the relative distances from the centre of gyration being considered equal, the greater density of the older amorphous masses would occasion their being impelled further from the centre; and consequently cause them to perforate, or to raise up the superincumbent or lighter strata, when the whole concentric mineral envelope of the non-rotating sphere burst asunder and became transformed into continental ridges, oceanic hollows, hill and dale, by the centrifugal impetus of the earth's protorotation, occasioned by the introduction of the Light into the material universe.

With reference to what was stated at the conclusion of the foregoing chapter, the first point to which the attention will now be directed, while endeavouring to establish it, is the relative insignificancy of the estimated thickness of the *earth's outer crust*, in comparison with its *entire radius*. With this view, let us, on commencing, have recourse to the *twenty-first* Theorem, to be assured that there is such a thing understood among geologists as an "outer crust of the earth." *All geologists make use of terms indicating, that their discourses have reference to an "external crust," "outer coating," or, as it is sometimes called, "shell" of the earth, but generally without explaining to what depth these are considered to penetrate into the viscera terræ; yet sufficient has been said to show that these expressions are considered to refer to that which has limits not far from the surface; and even, in a few instances, an attempt has been made to draw a clear line of separation, at no great depth below the surface, between the solid crust and the supposed internal masses.*

In selecting evidences from among the numerous authorities for that opinion, I shall give what may be considered the expression of a pretty general one on this point, since Dr. M'Culloch takes it up with the intention of *refuting it*, when treating on "*the depth of the strata beneath the surface.*"

"It has," he says, "been ignorantly made a matter of reproach to geologists, that they reason respecting the structure of an earth to which they

have had no further access than by operations that ought to be considered but as scratches on it surface. It has been said that the highest mountains are but as dust, and the deepest mines but as invisible punctures on a common geographical globe."*

Although he endeavours to set aside the main bearing of this upon the geological points then under his discussion, he concludes by giving it as *his* opinion,

"That we have no reasons *a priori* for supposing that strata deposited from an ocean, however ancient, can exist beyond a certain, however undefined depth."†

"When we examine," observes Mr. Lyell, "into the structure of the earth's crust (by which we mean the small portion of the exterior of our planet accessible to human observation), whether we pursue our investigations by aid of mining operations, or by observing the sections laid open in the sea cliffs, or in the deep ravines of mountainous countries, we discover everywhere a series of mineral masses which are not thrown together in a confused heap, but arranged with considerable order; and even where their original position has undergone great subsequent disturbance, there still remain proofs of the order that once reigned."‡

"Beneath the whole series of stratified rocks," says Professor Buckland, "which appear on the surface of the globe, there probably exists a foundation of unstratified crystaline rocks, an irregular surface, from the detritus of which the materials of stratified rocks have in a great measure been derived—amounting, as we have stated, to a thickness of ten miles. This is indeed but a small depth in comparison with the diameter of the globe; but, small as it is, it affords certain evidence of a long series of changes and revolutions; affecting not only the mineral condition of the nascent surface of the earth, but attended also by important alterations in animal and vegetable life."§

A recent popular work contains the following evidence respecting not only the assumption of the earth having an outer crust, but also its presumed thickness. It is given in reference to Part II. of Mr. Henessy's *Researches in Physical Geology*, communicated to the Royal Society by Major Beamish: the part which interests us, at present, being Clause 2nd, which states that—

"By employing the values of the constants obtained in Section IX., it appears, that the thickness of the earth's crust cannot be less than 18 miles, and cannot exceed 600 miles."||

And still more recently, on this much debated subject, the following hints transpire in the inaugural address of Professor Hopkins, at the last meeting of the British Association at Hull, when treating of the prevailing favourite speculations, as to the internal condition and temperature of the earth.

"Hence," says he, "the opinion adopted by many geologists is, that our globe does really consist of a solid shell not exceeding 40 or 50 miles in

* Geology, vol. i. p. 94. † Ibid, p. 96.
‡ Principles of Geology, vol. iii. p. 8. § Bridgewater Treatise, vol. i. p. 42.
|| Year Book of Facts, 1850.

thickness, and an interior fluid nucleus, maintained in a state of fusion, &c. It might, at first sight, appear that this enormous mass of molten matter, enclosed in so thin a shell, could scarcely be consistent with the general external condition of the temperature of our globe, but it is quite certain that these are not inconsistent with each other; and that no valid argument can be urged against the hypothesis."*

While it is to be regretted that the present state of science, in its attempts to penetrate into the *viscera terræ*, should be accompanied by results so vague and indefinite as to be almost of no value, nevertheless, such is the strength of the position assumed, that in conducting the argument I can afford to take the *mean* of all these divergent estimates, even including the extreme one revealed by Mr. Henessy's mathematical researches, as the thickness beyond which it cannot be. As a corroborative process, however, an equally conclusive deduction can be come to by comparing the height above the sea level of the most elevated mountain ranges on the face of the globe with its radius, or semi-diameter. On this subject the following pointed and convincing testimony will close this part of the evidence:

"The surface of the sea," observes the accomplished author of *The Connexion of the Sciences*, "is therefore spheroidal, and the surface of the earth only deviates from that figure when it rises above or sinks below the level of the sea. But the deviation is so small that it is unimportant when compared with the magnitude of the earth; for the mighty chain of the Andes, and the yet more lofty Himalaya, bear about the same proportion to the earth, that a grain of sand does to a globe three feet in diameter."†

If, therefore, the estimated elevation of nearly 27,000 feet be thought unworthy of being taken into account, when estimating the diameter of the earth, neither is the mean thickness of the earth's crust comparatively worthy of notice. Thus we have come to one certain conclusion for determining the question at present under discussion. It is this: that during the non-rotatory period of the earth's existence, the perpendicular distance, from the surface of the coal measures to the inferior strata which repose on the unstratified rocks, was so insignificant, in comparison with the radius of the earth, that for any purpose wherein those two limits require to be adduced, they may be assumed—for all practical purposes—as equidistant from the centre of gyration.

We must next endeavour to determine the relative densities of the several classes of rock, especially of the primary and older stratified masses; and of the more modern of the secondary formations, in order to institute a comparison between them; though it is somewhat difficult to arrive at this point with any degree of precision, for it seems hitherto to have attracted but little attention as a specific question; nevertheless, there is abundance of evidence to prove, in a general way, the received opinion, that our globe is formed of materials whose density increases from the surface towards the

* Athenæum, p. 1068, Sept., 1853.

† Connexion of the Sciences, p. 8.

centre. In support of the point, *generally*, sought to be established, namely, the greater specific gravity of the older rocks, I offer, first of all, the following clause from the *twenty-third* Theorem :—"*That they (geologists) also concur in considering the primary rocks, besides being deficient in inorganic remains, to be more compact and crystaline in texture than the others.*" The following are some of the authorities for that opinion :—

"When we trace," says Dr. Fleming, "the characters of the different depositions which have taken place, from the newest alluvial beds to the oldest transition rocks, we witness very remarkable gradations of character. The newest-formed strata are loose in their texture, and usually horizontal in their position. In proportion as we retire from these towards the older formations, the texture becomes more compact and crystaline, and the strata become more inclined. These characters may be traced by comparing the common loose marl of a peat-bog with the former chalk; the compact floetz limestone with the transition marble; or the peat itself with the older beds of wood coal, or the still older beds of coal of the independent coal formations. The organic remains in the newer strata are yet unaltered in their texture, and easily separable from the matter in which they are embedded. In the older rocks the remains are changed into stone, and intimately incorporated with the surrounding rocks. These facts make us acquainted with the original condition of the matter with which the organic remains were enveloped, and lead us to believe that the bed now in the form of limestone or marble was once loose as chalk, or even marl; that coal once resembled peat; and that the strata of sandstone and quartz rock were once layers of sand."*

Sir Henry de la Beche, when treating of the *Non-fossiliferous Stratified Rocks*, says—

"From various circumstances, many of the lowest fossiliferous rocks assume the mineralogical character of those in this class so as to be indistinguishable from them, except by geological situation; but it may be assumed that, as a mass, the strata in this division are far more crystaline than in those of the superior stratified rocks, the origin of which seems chiefly mechanical."

Mr. Lyell, in one short passage, when treating of the *Metamorphic Rocks*, says—

"Nor should it be forgotten that, as a general rule, the less crystaline rocks do really occur in the upper, and the more crystaline in the lower part of each metamorphic series."†

Professor Phillips, in his Treatise, says—

"Induration, or consolidation to a high degree, is a general property of the primary strata, composed of siliceous, argillaceous, and calcareous rocks. There is, in fact, no sand, no clay, no marl in the whole series."‡

Besides these general evidences, we are, fortunately, supplied with proof of a more specific character by the accurate experiments made

* Letter in Edinb. Jour. No. 15, January, 1823, pp. 120, 121.
† Elements, vol. ii. p. 416. ‡ Page 71.

by Lord Webb Seymour and Professor Playfair, on the mountain of Schehallien, and whose results have been given to the world by the latter accomplished writer. The whole is so interwoven together, and dependent on mathematical calculations, that a satisfactory abstract can hardly be formed of it, but the following short extract seems to convey all the evidence which is required for the present:—

"One thing only seemed wanting," says Professor Playfair, when alluding to Dr. Maskelyne's astronomical observations made on that mountain in 1774, "to give to the determination of the earth's density all the accuracy that could be obtained from a single experiment, namely, a more accurate knowledge of the specific gravity of the rock which composes the mountain, as being the object with which the mean density of the earth was immediately compared. The specific gravity of that rock was assumed to be to that of water as 5 to 2, which, though it be nearly a medium when stones of every kind from the lightest to the heaviest are included, is certainly too small for Schehallien, the rocks of which belong to a class of a specific gravity considerably above the mean."*

After giving the particulars of the various specimens employed, and tables of their individual densities, he goes on to state—

"From the inspection of the preceding table it is evident, that the specimens relatively to their specific gravity may be divided into two classes, sufficiently distinct from one another. The specimens of granular quartz are in spec. gr. comprehended between 2.61 and 2.66, nearly; and the mean is 2.639876. The micaceous rocks, including the calcareous, are contained between the limit 2.7, and 3.06; the mean of all the 15 specimens being 2.82039. Now it happens fortunately that these two classes of rocks distinguished by their spec. gr. are also distinguished by their position, so that the line which separates them can be accurately traced out on the face of the mountain."†

From what has now been said another important *datum* has been acquired to enable us to continue our present enquiry; for we have been made aware by these evidences, that the stony masses which constitute the unstratified rocks, their associated schists, and the older stratified formations, generally speaking, exceed in specific gravity the latter ones, which are not so perfectly consolidated from age or pressure. Or, in other words, *that the specific gravity of the earth's rocky crust, of the ancient globe, increased in proportion to the distance from the submarine surface of that period.*

* Playfair's Works, vol. iii. p. 404.

† Ibid, p. 421. The result of these delicate lithological experiments, although in their general tenor affording the favourable testimony expressed in the extract above given, yet reveal an anomaly which candour induces me not to conceal; I allude to the circumstance of the micaceous and calcareous specimens being of greater specific gravity than the granitic, which form the apex of the mountain, and which, according to my views, ought to have been the heaviest. At first this appears an irreconcilable difficulty, but on applying the 53d Theorem to it, it serves to confirm another very interesting truth, namely, that although the granitic mass, previous to being fused by friction, was of greater specific gravity than those which overlaid it, on crystalizing it expanded, while the aluminous contents of the others, on heating, became contracted, and thereby a change of relative densities took place.—Author.

With these data, namely, the greater specific gravity of the older or *then* inferior rocks; and the equality of distance at which the upper and under surfaces of the stratified envelope of the globe, for all parallels of latitude, may be considered to have been in relation to the centre of gyration, let us recur to the laws of mechanics, and endeavour to discover what would be the effect of the rotation of the earth on materials so circumstanced. It will be found stated in a part of the *seventy-third* Theorem, "*That weights which are as one to two at equal distances, with the same velocity, will have their centrifugal force increased as the mass of the moving body increases.*"

This rule embraces all the circumstances of the case which are now under investigation; for, by the rotation of the earth around its axis, the angular velocity, and consequently the centrifugal impetus, was the same for all places on the same parallels of latitude; the perpendicular distances, between the upper and under surfaces of all formations overlying each other, might for each mass be considered equally distant from the centre of gyration; while their relative densities, although not as one to two, were sufficiently diverse to cause a difference in their centrifugal impetus, and according to the above law, the heaviest would be made to fly further from the axis of the earth, which, in this case, was also that of gyration.

This, then, is another step towards the termination of this part of the enquiry; for we have been made aware, that when the globe was made to revolve, there would be unequal centrifugal forces engendered among the several masses constituting the envelope of the spherical earth; and in order to come to a final conclusion, there requires only now to combine it with what was established when the *seventy-eighth* Theorem was formerly applied, namely, "*That the centrifugal force overcame the cohesion among the parts of the earth's outer crust, and caused them to burst asunder, in order to assume the oblate form corresponding to the rotatory motion with which it was impressed.*" For the combination of these conditions must persuade us, "*That in the general movement which took place among the stony masses constituting the earth's outer crust, when thus broken up, and unequally impelled from the centre, the undermost or heaviest would be caused to perforate or heave up, if they did not entirely pierce through, the stratified masses which reposed upon them.*"

This conclusion, it is considered, must, of necessity, be come to, as the legitimate deduction of what has been stated in the preceding argument.

No doubt, the diverse increments in the centrifugal impetus according as the zones were nearer to the equator, and the oblique action towards the polar regions, of gravitation upon this newly-engendered force, will together eventually aid in removing the difficulties which, at present, interpose to prevent a satisfactory account being given for the peculiar sweep which the three great continen-

tal ridges have assumed, as well as for the particular lines of direction which mountain chains took when they alike rose up, at his command, and "stood fast." The chief difficulty in this branch of enquiry consists in our ignorance, as to the way in which the crust of a world should break up when caused to fly asunder by the sudden impetus of protorotation. This, however, would in some degree be obviated were we to admit that deposition, by means of the great luni-solar current, and of animal and vegetable agency, may have been so arranged and carried on, that there were sutural lines (similar to those which occur in other natural objects), prepared parallel to the axis, whose divergence from perfect parallelism, when they became apparent by dehiscence, was occasioned by the action upon them of the forces engendered by protorotation.*

It is not intended, however, to push this particular point any farther; it is merely alluded to as one with regard to which the Dynamical Theory will be found to lend much assistance; especially to those who are dedicating profound mathematical reasoning to the solution of the great problem of the inequalities of the earth's outer crust. Fortunately, the general argument can be prosecuted altogether irrespectively of this investigation, and it will accordingly be proceeded with.

* Eleventh Theorem.

SECTION IV.

INTRODUCTION OF THE LIGHT; THE CONSEQUENT PROTOROTATION OF THE EARTH; AND ITS DYNAMICAL RESULTS.

CHAPTER XVIII.

Introductory advertencies. Modification, according to latitudinal zones, of the dynamical influence of the Earth's first diurnal motion. Several distinct effects which proceeded coevally from the centrifugal impetus engendered by protorotation. Evidences of this having taken place *after* the stratiform masses had been deposited and become indurated, deducible from the diversified surfaces assumed by the *terraine* and by the *aqueous* portions of the Earth, as co-results of the same cause. Evidences to the same effect derived from the great continental ridges and oceanic depressions of the globe. And finally, the strong testimony which these geological and geographical manifestations, together with the filling up of the equatorial inequalities with deep and widely-spread masses of travelled mineral debris and earthy matter, bear to the correctness of the Dynamical Theory.

BEFORE proceeding to trace more circumstantially, the important results emanating from the general convulsion of the earth's rocky frame, in accommodating its masses to the modified form which its protorotation caused it to assume, it may be proper to make the following opportune advertencies.

The effects proceeding from the dynamical law which has just been contemplated, are to be considered applicable more especially to points of equal latitudes; and to hold good with regard to all masses immediately superimposed on each other; whilst a different and more complex rule requires to be applied, when it is wished to ascertain the comparative results for points of divergent latitudes. In consequence, for example, of parts within 25° of the equator being at much greater relative distances, from the common axis of gyration, than those of higher latitudes, and, consequently, falling within the dominion of the second rule of the *seventy-third* Theorem, a somewhat different effect would take place with regard to them. For although the circumstances, mentioned in the previous argument, would undoubtedly cause all more weighty rocks to rise up from beneath the incumbent ones of less dense material, *at every point along the whole line of axis, except when very near to the poles*: it follows, from the observation just made with respect to unequal distances from the centre of gyration, *that the violence of protrusion would not only be in proportion to proximity to the equator, but under a parity of*

circumstances, the whole moveable mass, upper, and under, and all between, would, within the tropical zone, be forced farther from the axis, and thereby caused to form more elevated continents and deeper oceanic hollows.

The revolution of the earth around its axis having been the cause of innumerable important phenomena, radiating from it as a common centre, they were consequently all undergoing their phases, assuming their forms and states, and speeding to their respective destinations at one and the same period of time; and therefore, in order to assimilate the description to the events which took place, they should, were it possible, be all described simultaneously. But as many details require to be gone into, several difficulties to be overcome, evidences to be brought forward, positions laid down, and conclusions drawn from the whole, this rapidity of description, however desirable, cannot be accomplished, for some order of sequence must be observed; hence the necessity for this advertence, that the mind may be prepared for the unavoidable discrepancy which must, of necessity, take place between the simultaneous rapidity of the events themselves, and the unavoidably dilated explanation which is about to be attempted of them. For with man's circumscribed faculties, we are constrained to submit to sequence in all subjects which engross the attention, and more so, when it is of so complex a character as a description of the earth rising, at the command of the Great Creator, from beneath the water which had so long encompassed it; and by one vast effort sending forth enormous mountain chains; scattering massive boulders and blocks; forming breccias and conglomerates; engendering fusion by inconceivable heat from friction; causing the deposition of extended areas of strata mechanically formed; and giving birth to an irresistible rush of water from the poles towards the equator; almost all synchronous, or during the first two days of the Mosaic week.

If the positions which I have assumed be correct, the deductions hitherto drawn be exact, and the mechanical laws have been properly applied, we should be able to deduce therefrom, that very important transformations necessarily took place in the form and surface of the spherical non-rotating earth—covered, as it was, by a circumfluent ocean—when it was first caused to revolve around its axis.

Hitherto it has been customary to consider that the earth assumed its oblate form, or that which corresponds to rotation, while it was yet in such a state of fluidity as to admit of perfect mobility amongst its particles; and thereby became, as is usually expressed, "flattened at the poles, and protuberant in the equatorial regions."* These assertions, however, can be admitted as perfectly correct, provided only that a clear line of distinction should be drawn between the *Aqueous* and the *Mineral* portions of the earth. In the former

* Astronomy, by Sir John Herschel; Connexion of the Sciences, by Mrs. Somerville; and others.

there was a flattening at the poles; in the latter *there was none.* Indeed, one of the most essential dogmas by which the present theory is distinguished from all others, and by which its truth is hereafter to be tested, consists in the fact, *that with respect to the solid materials of the earth, there was no flattening at the poles.* This *diameter* of the globe (for there were then no poles), is considered to have remained—as far as the *solid materials are concerned*—the same as when the earth existed in a spherical form circulating through space, but before it was impressed with rotation; *the change in diameter, from those of a sphere to its actual spheroidal dimensions, having been effected by a decrease in the aqueous portion at the poles, unitedly with an enlargement of the surface and general diameter of both the solid and aqueous portions around the equatorial regions.*

In order more thoroughly and perfectly to comprehend, what is proposed to be stated respecting the results which proceeded more immediately from the earth's protorotation, there must beforehand be taken into account, those which would arise from two very distinctly constituted spheres being put into rotatory motion by the same force, namely, one sphere composed of solid matter, and another, a hollow one, of water; both containing a determinate quantity of matter, the latter being borne on the surface of the former.

In reasoning, with respect to these, the liquid hollow sphere may, at once, be disposed of, by conceding what actually took place, namely, that a sudden conflux of its water, from the poles towards the equator, caused this moveable hollow sphere to become flattened at the poles, and protuberant at the equator, by a transfer of its particles from the one part to the other, in order to complete that perfect form of equilibrium which the ocean alone presents; while it is to be remembered, that it was enabled to do this merely because the molecules of its mass were so constituted, with regard to each other, as to admit of perfect mobility in all directions, and thereby of their arranging themselves, when the entire mass was accommodating itself to the new form of rotation, so as to adopt a level surface throughout its whole extent.*

The concession of this point produces spontaneously the following two important conclusions:—1st. That the water was then under the same laws as at present, of which more hereafter; and 2ndly. That had the portions of the earth, now solid, been then in such a state of fluidity, either from aqueous solution or from igneous fusion, as would have admitted their assuming an oblate form by a transfer of particles, or becoming in the same manner flattened at the poles, with a corresponding protuberance at the equator, they, likewise, would, in obedience to the laws affecting fluid bodies in revolution, have assumed, at the same time, *a perfectly level surface*, similar to that adopted by the hollow sphere of water which has just been contemplated, for they were both subjected to the

* In accordance with what is stated in the 89th Theorem.

same centrifugal force in quality and degree. Under these circumstances there can be recognised no reason why the mineral portion of the earth should be supposed to have been possessed of sufficient fluidity to admit of its having assumed the spheroidal dimensions by a flattening at the poles, and corresponding protuberance at the equator, *while there is denied to it the adoption of the other consequences which would inevitably have followed from the same degree of fluidity.* It is of the utmost importance to be consistent in opinion, and I therefore quote what has been said by scientific writers on the subject under consideration. In the Cabinet Cyclopædia it is stated—

"Indeed, this theorem" (proving the tendency of water to assume and maintain its level) "is nothing more than a manifestation of the tendency of the component parts of every body to fall into the lowest position which the nature of their mutual connexion, and the circumstances in which they are placed, admit. Mountains do not sink and press up the adjacent valleys, because the strong cohesive principle which binds together the constituent particles of their masses, and those of the earth beneath them, is opposed to the force of their gravity, and is much more powerful; but if this cohesion were dissolved, these great elevations would sink from their lofty eminences, and the intervening valleys would in their turn rise—an interchange of form taking place; and this undulation would continue until the whole mass would attain a state of rest, when no inequality of height would remain. All the inequalities, therefore, observable in the surface of land are owing to the predominance of the cohesive over the gravitative principle; the former depriving the earth of the power of transmitting, equally in every direction, the pressure produced by the latter."*

Whoever, therefore, maintains that the important transformation alluded to occurred while the globe was fluid, will have to explain, according to his own hypothesis, why the mineral portion did not adopt a perfectly level surface, and undergo a change *from a level sphere to a level spheroid.* That this did not take place was fortunately and providentially ordained otherwise; and we must therefore look to some other source, for a more correct and comprehensive elucidation of the cause whereby it is so differently constituted in its two important elements—land and water.

In doing this I shall commence by assuming the following limiting positions :—1st. That there was not a *transfer of solid material* from the polar to the equatorial regions, when the change of the earth's form took place, sufficient to effect its transformation into that of equilibrium ;† and 2ndly. That assuredly there *was* an enlargement

* Treatise on Hydrostatics, Cab. Cyc. pp. 57, 58.

† When it is said "there was not a transfer of solid material took place," these terms are not meant to be an unqualified negative; for I shall have to show, in the sequel of this discourse, that there was a vast quantity of loose material borne by the conflux of the water from the poles to the equator, which *filled up the rude and deep acclivities of these regions.* But this did not in any manner contribute *to produce the outline form of equilibrium,* although it served to round it off, and render it more productive and habitable. It is in this latter sense merely, that of the general outline, that the expressions above used are designed to be negative.—AUTHOR.

of the equatorial surface and its general diameter;* which two limiting assumptions force us into the conclusion, *That only such a transformation of the surface occurred as served to fulfil the conditions of the new state to which it was subjected when caused to rotate.* As the only change in the form of a spherical body, to which no addition from the polar extremities is made during the process, while an actual enlargement of surface ensues, is that *which transforms it into ridges and corresponding hollows*, it therefore results, that one of the most prominent effects of the centrifugal impetus upon the earth, constituted as it is supposed to have been, would transform its surface (enlarging it at the equatorial regions) *by the addition of material from within*, into immense continental ridges and oceanic hollows, whose direction would, in general, be in lines parallel to the axis of rotation, modified by a variation in the intensity of the elevating force, occasioned by the form of the revolving body; and whose elevations and depressions would increase in proportion as they approached the equatorial regions.

That this is the form which its surface has assumed, the *eleventh* Theorem will satisfactorily prove. It is therein stated, "*That on taking a general view of the great geographical outlines of the world, it is seen to be divided, in directions nearly parallel to its axis of rotation, into three great continental ridges, namely, that of North and South America, with the intervening archiepelago; 2nd, Europe and Africa; and 3rd, Asia and New Holland, with the Polynesia, which intervene. That there is a remarkable similitude in the general contour of these three great divisions, especially between the first and the last, seeming to indicate that their form is due to a common cause. And that within the equatorial zone are situated the most extensive table lands, and the greatest number of islands.*" While I refer to any geographical map for the correctness of what is stated in that Theorem.

Besides the evidences arising from the *outline form* of the great continental ridges, there are likewise satisfactory proofs discoverable in favour of this part of the dynamical theory, in the relative position of the component rocky masses themselves, as will be seen by perusing the *twenty-eighth* Theorem, which states, "*That it is not only the greater geographical height of the inter-tropical mountains which denotes the presence of a comparatively increased force in the regions where they are elevated, but their geological structure corroborates the same assumption. For, 'rocks similar to those which constitute the ridge of Jura in the Alps, are found to occupy the plains of England; and basalts which repose on the granites of the Andes are discoverable beneath the limestone of Skye.'*"†

* These qualified expressions are used from the belief, that there are parts of the earth's equatorial regions now covered by the ocean, which, if estimated from the solid surface of the antipodes, would, perhaps, be found to measure less than the polar diameter.

† Geology, by Dr. M'Culloch, vol. i. p. 8.

On a retrospective view being taken of what has been said with regard to the change which took place "in the twinkling of an eye," as it were, in the form of the earth, from a non-rotating sphere to a spheroid of rotation, perhaps no evidence could be adduced which militates more against the conceptions, hitherto entertained, of its having assumed the oblate form while in a fluid state, than the circumstance of there actually having been two spheres, the one fluid, the other rigid, superimposed on each other, and subjected simultaneously to the same impetus. For this remarkable coincidence leaves the theories, which are formed on the supposition of fluidity, without the shadow of a foundation; it brings them to the touchstone at once, and reveals their unsoundness, by furnishing an example in point, in which, one of the spheres being fluid, in accommodating itself to the change, has not adopted a surface of undulating elevations and depressions, but moving on the face of the more rigid mineral sphere, has arranged itself in perfect horizontality: and unless it can be proved (but what no one will ever attempt to do), that the impelling force applied to the aqueous portion was different from what was exerted on the mineral mass, some other source must be looked to for the cause of the differences of form and surface which, under similar circumstances, they have assumed; a difference only to be accounted for by admitting what was really the case, that the one was liquid, and obeyed the laws which govern matter in that state, while the other was so far rigid, that although the cohesion among its parts was overcome to a certain extent by the centrifugal impetus, yet it impeded the transmission of sufficient mineral matter from the poles to the equator to *fill up the perfect form of rotation, and to round it off into a revolving spheroid of level surface.*

A few moments of reflection will convince any one that the diversity observed by these two spheres—the outer pliant and moving like an elastic ring upon the other, while the mineral one remained invariable in polar diameter—was wisely ordained by the Creator, in order to form those open cavities, or hollows, which were destined to confine the water when "it rushed forth as from the womb," and to separate it from "the dry land;" likewise to adorn the earth with that charming diversity of land and ocean, hill and dale, river and lake, which render it so fit an abode for those creatures for whom it was prepared. The theatre, alas! of all their ingratitude for the wisdom, goodness, and power which were lavished in preparing it for them!

There are seldom any attempts made to explain the origin of the continental ridges and oceanic hollows into which the earth's surface is so prominently undulated. These appear either to have been looked upon as necessary parts in the form of a world, or to be entirely beyond the limits of geology. Whether they *should* form a part of that pleasing and instructive study will not at present be enquired; but certainly they ought not to be overlooked in any

treatise having for its object to account for the formation of the earth. They are very prominent features on its surface, and should therefore occupy a corresponding place in all cosmographical treatises; while it may very safely be affirmed, that they *could not be in existence without having had an adequate cause.* This explanation, therefore, is offered as an additional feature in favour of the dynamical theory, which not only does not shrink from nor overlook them, but would not be true if these immense elevations and cavities *did not exist. They are the necessary consequences of the earth having been caused to rotate,* AFTER *the greater part of its stratified material had been deposited in concentric layers upon its submarine surface, and of the existence of the watery envelope which everywhere surrounded the non-rotating sphere.*

It is likewise presumed that the prevalences of islands within the equatorial zone—noticed in the *eleventh* Theorem—is another proof of the correctness of the dynamical theory. Islands are the apici of submerged mountains, and evince at one and the same time the increase of the centrifugal impetus in those regions, and conflux of the water thither from the poles; the wisdom and the goodness of which binary arrangement are very manifest! Had the former not taken place with sufficient force to have thrown up these mountains, the equatorial portion of the globe would have been an unbroken, wearisome waste of water—a liquid, unproductive zone! On the other hand, had the latter been wanting, it would have been a rugged and impassable girdle of arid mountains! But by the manifold wisdom of the Creator, and the fitness of his arrangements, it is not lost to usefulness, either by the one extreme or the other, their harmonious combination rendering it easy of access, fruitful in soil, and salubrious in climate, the fierce rays of the tropical sun being mitigated by the abounding water, which likewise facilitates the communication from zone to zone, and from hemisphere to hemisphere.

It must have appeared obvious to the reader, by what has hitherto been said, with respect to the great continental ridges, that they have been merely treated of in general terms, and presented to the view only as outlines—a rude mineral skeleton of towering peaks and sharp acclivities, such as might be conceived to arise, when one mass of bare rock was caused to perforate another by the violence of the centrifugal impetus, but which had not yet been filled up, or rounded off, by the deposition of the immense mass of *debris* spoken of in the *thirty-second* Theorem. The process by which this transformation was effected, and this part of the earth rendered a fitter habitation for man and the terrestrial animals, will be fully explained when I close in upon the subject, and treat it in a more definite manner, with reference to stratified masses superimposed on the unstratified ones in a determinate order, subjected alike to a force of known rate and direction, capable of dislodging both from their

recumbent posture. Then it will be recognised, that there was a mass of debris spread abroad, which can only be accounted for by supposing that it went to fill up rocky hollows such as have been already alluded to; while it will be my care to explain how great a proportion of it was swept by the rush of the polar water to the equatorial regions, and, being there spread abroad upon its rugged and rocky surface, conduced to round it off, and to render it more habitable.

In further confirmation of this view of the case, without going into particulars (which will presently have to be done), it may be generally observed, that *denudation* is a geological feature, which writers in that science have occasion to insist much upon when they are describing formations in high and even moderate latitudes, such as those of our own country. The respective works of MM. de la Beche, Phillips, and Lyell, abound with passages descriptive of the effects of denudation by water. When the same writers, however, have to direct the attention of those whom they are instructing to the regions within the tropics, and near to the equator, they require to bring forward evidences of vast accumulations of water-borne stratified material which have filled up hollows and rounded off sharp acclivities amongst widely extended table lands. For example, the description given by the first of these,* from the writings of Humboldt, of the plains of Mexico and New Granada, and the more recent and admirable description, by Mr. Lyell, of the valley of the Mississippi, all of which, and especially the contrast they present, between the leading developments of these two divergent regions of geological research, are precisely in keeping with what there is reason to expect would result as the effects of the centrifugal impetus and the rush of water from the poles towards the equator, which took place on the protorotation of the earth; while the denudation in the higher latitudes, and the corresponding deposits in the tropical regions, afford the most conclusive evidence *that the waters did not return;* but having carried their earthy load and deposited it where they came to rest, by assuming their static form of rotation, they were there constrained for ever afterwards to remain, and to produce those desirable and needful effects to which allusion has been made above. It should be noticed, at the same time, that this result would be accomplished by a transference of waters from the polar extremities in quantity corresponding to a depth of about 6½ miles, or half the excess of equatorial radii over those corresponding to the earth's other two semi-diameters.

I confess I am quite incapable of determining, by reasoning *a priori,* whether the number of three great outline ridges—into which the earth is divided—be that into which a world such as ours in dimensions, geological structure, and impelled by an angular velocity of 15° per hour, ought, from secondary causes, to have

* Manual of Geology, pp. 409—412.

been broken up. This interesting problem may probably form the subject of future investigations, and it is not doubted *but that it will then be found to have been the result of secondary causes.* I am, however, convinced, that all things were previously disposed so as to enable the terraqueous globe to assume its present tripartite continental divisions, with their respective accompaniments, as the necessary results of secondary causes, themselves the effects of immediate causes emanating from the Omnipotent Creator of all, "without whom was not anything made that is created and made."

Proceeding with the argument, the reader must now be reminded, that in a former part of this section it was laid down as ascertained data, that the consecutive layers of rock which formed the outer crust of the non-rotating sub-marine earth, *increased in density as they receded from the surface.* Also, that the distance of the upper and under surfaces of the stratified envelope might, for all practical purposes, be considered equi-distant from the centre of gyration. To the geological phenomena, circumstanced as thus stated, there will now be applied the last clause of the *seventy-third* Theorem, wherein it is asserted "*That all other circumstances being equal, 'the centrifugal force increases as the mass of the moving body increases.'*"

If the deposited strata, at the bottom of the original ocean, be conceived to have been lying horizontally, in a determinate order of superposition, at the time when the above law was brought into exercise by the rotation of the earth around its axis, whereby centrifugal impetus was impressed alike upon all the rocky masses of its terraine crust; it will appear obvious that, when they started from their recumbent postures to assume their respective places in the new order of things which was to follow, when the transformation from a sphere to a spheroid took place; the heaviest—all other circumstances being equal—would be caused to fly farthest from the centre of gyration, "the centrifugal force increasing as the *mass* of the moving body increases."

From what has already been explained, it has been seen that the *undermost* were the *heaviest;* consequently, in obeying the new law thus impressed upon them, they might either have perforated the stratified rocks above, and thrust their rugged and pointed summits, in towering grandeur, above all around them: the superincumbent stratifications, from being also impressed with centrifugal impetus, and possessing considerable molecular cohesion, might have resisted the perforating action of the inferior masses, and the whole group have swelled out into a mountain form, with summits capped by stratified material, in disjointed massive blocks suitable to the enlargement of superfice which together they had undergone; or, lastly, a modification of these extreme cases might have taken place, and the unstratified rocks, while they partially perforated the strata, might have forced other parts of them into elevations along with themselves, assisted by the centrifugal impetus imparted to the

accompanying strata; in which case, the apici of the mountain would consist of amorphous rock, presenting high pointed peaks, with shoulders and flanks, composed of those stratified materials which accompanied the nucleii to a certain extent in their rise from horizontality. And, finally, as the strata were elevated by the impetus of underlying masses, which, in moving from below upwards, assumed a pyramidal form, they would be raised to the greatest elevations, and into positions approaching nearer to verticality in proportion to the priority of their deposition, or their inferiority in the order of stratification.

According to these views it is obvious, that diversified effects would ensue from the application of the centrifugal force to a sphere of such complex structure. The continental elevations and oceanic hollows, together with the general form of equilibrium, may be considered as the principal results—the greatest change of relative position to which its rocky masses were subjected. Mountains and valleys, more dependent on the nature of the masses immediately overlying each other, and on their latitudinal situation, would be brought forth indiscriminately on the surface of continents, or on that of the ocean beds; while these, in turn, would become studded over with lesser inequalities, from the unequal densities of their component elements, and other influences of a more local character. Thus we have one general cause, *the first rotation of the earth around its axis*—modified by the nature and situation of the materials on which it was made to act—employed by the hand of the Creator, in a moment of time, to change that which was "without form and void" into a world of infinite variety of surface, admirably adapted to fulfil the chief design of its creation: a richly adorned pedestal on which myriads of creatures, of widely diversified habits, are nurtured and reproduced in almost endless succession, "each after his kind," and designed to glorify him, who, in wondrous wisdom, made them all; while they are wheeled so smoothly through space as to have required the intellectual labours of generations of astronomers, to convince the human race, that the planet they inhabit is not absolutely immovable in the clear blue vault of heaven. And now, most probably, it may prove as arduous an undertaking to convince their descendants, that what their forefathers wrongfully maintained as an immutable law of the system, even to the persecution of those who asserted to the contrary, *was once actually the case*, and that the revolving globe, on which they stand, has passed through a period of non-rotation so protracted as to warrant the surmise, that it may have much exceeded even that of its known diurnal motion.

SECTION V.

GEOLOGICAL PHENOMENA RESULTING FROM THE EARTH'S PROTOROTATION.

CHAPTER XIX.

Introductory remarks. Classification of rocks into STRATIFIED and UNSTRATIFIED. Geological data for the correctness of these two great divisions. Evidences in favour of the Dynamical Theory, deducible from the *unstratified* rocks. Nucleii and centres of mountain chains generally composed of amorphous masses. Their prevalence on the Earth's surface. Geological attestations in support of this. Axis of elevation observable in mountain ranges, and the conical form which their eminences have assumed. Argument, founded on the *stratified* rocks, to show, that the mineral crust of the Earth has been moved, in mass, from where it was formed. Firstly. Strata deposited horizontally at the bottom of the water. Geological evidences to this effect. Secondly. That they have been elevated from the position in which they were deposited, proved by numerous evidences. Concluding observations arising from the establishing of these several assumptions.

HAVING, at length, entered within the more immediate domain of Geology, its powerful aid will assist us in demonstrating the validity of those assumptions which have been endeavoured to be sustained in the preceding part of this work, and more especially in the last section. Those who may not have given much attention to the study of geology, or made themselves acquainted with the nature of the researches peculiar to this branch of science, may, perhaps, feel some surprise on perceiving that I am so disposed to lean, with such implicit reliance, on what it can do; but when they reflect, that the objects, with which geologists are conversant, are appreciable by the senses, can be seen, handled, and materially dealt with, and that these investigators have been the most assiduous and systematic, perhaps, of scientific labourers, their surprise will give place to unshaken confidence, when they remember that while those whose lot it was to convince mankind of the orbital revolution of this planet, had to appeal to objects external to the earth itself, and placed at vast distances in space, by whose relatively changing position they could manifest the rapid progress, in the clear blue vault of heaven, of the pedestal on which they alike stood, while the one asserted and the other denied the fact!—I, on the contrary, am constrained, from the altogether different nature of this subject, to seek, within

the compass of the sphere itself, for the chief sources of proof; and to point the finger, not to the rising splendour of the sun, or to the waning lustre of a setting star, but *to the material vestiges of change upon the globe itself*, to the adamantine symptoms, which yet remain, of the presence, in bygone times, of great and unusual dynamical influences on its rocky surface; and by their means, and the assurance derived from ocular demonstration, to endeavour to convince my readers, *that protorotation was not coeval with the commencement of orbital revolution, but followed after a lapse of ages*, and produced upon the indurated, laminated, submarine crust of the sphere, which the intervening period had allowed to be prepared and fitted, those vast and manifold changes which might have been expected, when a non-rotating globe, possessing a level, concentric, rock-bound shell, was caused to rotate around its axis, and transformed, by the centrifugal impetus, into an earth diversified by continents and oceans, hill and dale, and all the pleasing variety which now meet the eye, and render it so admirably adapted for its present inhabitants.

That geology, with its almost inexhaustible stores of authenticated facts, can supply the evidences which are now alone required to work out this great problem, I am fully persuaded; and I shall, therefore, without further prelude, call upon it to do so, while it is hoped the result will leave such impressions of conviction on the mind as shall neither be liable to be misinterpreted, nor capable of being set aside.

The *twenty-third* Theorem states "*That although a diversity of opinion prevails among geologists as to the origin, classification, and the nomenclature by which the greater groups of rocks composing the earth's outer surface are to be designated; nevertheless, an accordance has been come to as regards the unstratified amorphous masses, in contradistinction to all the stratified ones of every denomination.*

"*That they also concur in considering the primary rocks, besides being deficient in organic remains, to be more compact and crystaline in texture than the others, and generally more elevated in their positions. That they appear, in very many instances, to have been thrust up from beneath the strata, raising these up also, whether they have perforated or not wholly cut through them; in the former case remaining flanked by stratified masses, which repose upon them in evident inconformity.*"

What has just been said, will be sufficiently intelligible, without further illustration, to those who have paid any attention to geology; but, for the benefit of those who are not versed in that and kindred studies, an occasional extract is subjoined from some of the numerous authorities, to place the subject in a diversity of lights, in order that conviction may be impressed upon every mind.

"Unstratified rocks,"—Dr. M'Culloch observes—"have been produced from below the stratified. They are found below these, or above them, or intermixed in the form of masses, beds, and veins. The intermixture is attended by mechanical and chemical changes in the stratified rocks. They

have been consolidated after fusion, and their structure is necessarily chemical."*

Sir H. de la Beche says—

"Our knowledge of the structure of the earth's crust is far from extensive, and principally confined to certain portions of Europe. Still, however, a mass of information has gradually been collected tending to certain general and important conclusions, among which the principal are—That rocks may be divided into two great classes, the stratified and the unstratified; that of the former some contain organic remains, and others do not; and that the non-fossiliferous stratified rocks, as a mass, occupy an inferior place to the fossiliferous strata (or those which contain organic remains), also taken as a mass."

". . . . . . In the accompanying table, rocks are first divided into Stratified and Unstratified, a natural division, or, at all events, one convenient for practical purposes, independent of the theoretical opinions that may be connected with either of these two great classes of rocks."†

Although Mr. Lyell extends these two divisions to four, yet they may, with perfect propriety, be classified comprehensively into stratified and unstratified. The following is the description which Mr. Lyell gives:—

"I shall begin," says he, "by endeavouring briefly to explain to the student how all rocks which compose the earth's crust may be divided into four great classes, by reference to the different circumstances and causes by which they have been produced.

"The first two divisions, which will at once be understood as natual, are the aqueous and volcanic, or the products of watery, and those of igneous action at or near the surface.

"The *aqueous* rocks, sometimes called the sedimentary or fossiliferous, cover a larger part of the earth's surface than any others; and are stratified, or divided into distinct layers or strata. The term *stratum* means simply a bed, or anything spread out or *strewed* over a given surface, and we infer that these strata have been generally spread out by the action of water.

"The *volcanic* rocks are those which have been produced at or near the surface, whether in ancient or modern times, not by water, but by the action of fire or subterranean heat. These rocks are for the most part unstratified, and are devoid of fossils. They are more partially distributed than the *aqueous* formations, at least in respect to horizontal extension.

"But there are other two classes of rocks very distinct from either of those above alluded to, and which can neither be assimilated to deposits such as are accumulated in lakes or seas, nor to those generated by ordinary volcanic action. The members of both these divisions of rocks agree in being highly crystaline, and destitute of organic remains. The rocks of one division have been called plutonic, comprehending all the granites and certain porphyries, which are nearly allied in some of their characters to volcanic formations. The members of the other class are stratified, and often slaty, and have been called by some the *crystaline schists*, in which group are included gneiss, micaceous schist (or mica slate), hornblende schist, statuary marble, the finer kinds of roofing slate, and other rocks afterwards to be described.

* Geology, vol. i. pp. 12, 13.

† Manual, pp. 34, 35.

"Hence there are four great classes of rocks considered in reference to their origin; the aqueous, the volcanic, the plutonic, and the metamorphic."*

Professor Phillips, when comprehensively classing the rocks of which the earth's crust is composed, says:—

"The arguments on which we rely for the proof of the sub-aqueous origin of all the stratified rocks may be thus summed up:—

"The stratified structure is that which is always assumed by successive depositions of sediments of water.

"The materials (clay, sand, limestone, &c.) composing the strata of the crust of the globe are exactly similar and in the same condition, or else very analogous to deposits now forming under water in various parts of the globe, and similarly associated.

"The organic contents of the rocks are such as admit of no other explanation, for they are mostly of marine or fresh water origin, and the few terrestrial *reliquiæ* which occur in them show, by various circumstances, that they were drifted from the land or overwhelmed by the sea. By combining all these considerations, we arrive at the positive conclusion, that all *the really stratified rocks* are of aqueous origin. But when we turn to the unstratified rocks, the same conclusion does not apply. Independent of the universal want of this unequivocal mark of watery action, ... the following circumstances are decisive:—

"The materials of which the rocks are composed, are neither similar to those now deposited by water, nor in a similar condition. They are not composed of sands, clays, or limestone, but of a variety of crystalized minerals. . . . . .

"In these unstratified rocks, organic remains do not occur, ... and, from the whole evidence, no doubt remains of the igneous origin of the crystalized and other unstratified rocks."†

And again—

"It is remarkable that the lowest of all the known systems of stratified deposits should be at once the most extensive, the most nearly universal, the most uniform in mineral character, the only one from which organic life appears to be totally excluded, and in which the character of mechanical aggregation is the most obscure.

"The primary strata rest on unstratified, generally granitic rocks, so situated as to cut off all possibility of observation at greater depths. This granitic floor—this universal crystaline basis to the stratified rocks appears in many instances to have undergone fusion since the deposition of strata upon it, for veins pass from it into the fissures of these rocks. . . . . . It is enough for our present purpose that the general truth is recognised, that the stratified rocks, which are the products of water, rest universally on the unstratified crystaline rocks, which, through whatever previous condition their particles may have passed, have assumed their present character from the agency of heat. Igneous rocks, then, rest below all the aqueous deposits."‡

In corroboration of the foregoing position, with which it is inti-

* Elements, pp. 4, 15, 16. † Treatise on Geology, pp. 55, 56.
‡ Treatise, pp. 94, 95, 69, 70.

mately connected, there is adduced what is stated in the *twenty-sixth* Theorem—"*That the granitic, trappean, serpentinous, and porphyritic descriptions of amorphous rocks generally constitute the nucleii or centres of mountain ranges, and together with their recumbent strata attain the greatest elevations throughout the world. And that conjointly they occupy a considerable portion of its terrestrial surface.*"

The following are offered as some of its evidences:—

Professor Phillips says—

"The high mountain districts generally exhibit in the central points, or along their axes, granitic and other unstratified rocks under all their strata, which slope away on all sides at high angles of inclination, descend to lower and still lower ground, and, finally, pass under the plains and more level regions, and are there covered up and buried under other superimposed strata. Very few parts of the world offer real exceptions to this general statement."

And again—

"This leads directly to another very important law of the phenomena of disturbed stratification. The centre or axis of the mountain group, and consequently of the disturbing movement, is generally *seen* to be a mass of *unstratified rock*, such as granite, sienite, &c., which shows, by a variety of circumstances, that it was not deposited in water, but rather crystalized from igneous fusion."*

The following extract is from the pen of the graphic writer on the Old Red Sandstone:—

"I have often stood," says Mr. Miller, "fronting the three Rossshire hills, Suil Veinn, Coul Beg, and Coul More, at sun-set, in the fine summer evenings, when the clear light threw the shadows of their gigantic cone-like forms far over the lower tract, and lighted up the lines of their horizontal strata, till they showed like courses of masonry in a pyramid. They seem at such times as coloured by the geologist to distinguish them from the surrounding tract, and from the base on which they rest as on a common pedestal.

"The prevailing gneiss of the district reflects a cold bluish hue, here and there speckled with white, where the weathered and lichened crags of intermingled quartz rock jut out on the hill sides from among the heath. The three huge pyramids, on the contrary, from the deep red of the stone, seem flaming in purple. There spreads all around a wild and desolate landscape of broken and scattered hills, separated by deep and gloomy ravines, that seem the rents and fissures of a planet in ruins, and that speak distinctly of a period of convulsion, when upheaving fires from the abyss, and ocean currents above, had contended in sublime antagonism, the one slowly elevating the entire tract, the other grinding it down, and sweeping it away." . . . . .

"In most of our hills," he continues, "the upheaving agency has been actively at work, and the space within is occupied by an immense nucleus of inferior rock, around which the upper formation is wrapped like a caul, just as the vegetable mould, or the diluvium wraps up this superior covering

* Treatise, pp. 42, 43, 61.

in turn. One of our best known Scottish mountains—the gigantic Ben Nevis—furnishes an admirable illustration of this latter construction of hill. It is composed of three cones or rings of rocks, the one rising out of or over the other, like the cases of an opera glass drawn out. The lower one is composed of gneiss or mica slate, the middle one of granite, the terminating one of porphyry." While, "the elevating power appears to have acted in the centre, as in the case of Jorullo, in Mexico."*

"It is a familiar observation," says Dr. M'Culloch, "that granite forms the highest peaks and ridges of the most elevated mountains of the globe. The remark is, however, more common than true; it is certain that it constitutes many of these, but there are numerous mountains in the first class of elevations, that are formed of stratified rocks to the summits. Even where granite exists, it often forms only a portion of the highest points; the sides at very great elevations, and many of the ridges and peaks, being still constructed out of the superincumbent strata. In a certain limited sense, it may also be said, that trap forms the higher summits in mountains and hilly regions; a remark very conspicuously true in some parts of the enormous ridges of South America."†

"Granite," according to the same author, "is one of the most universal rocks, forming some of the highest and most remarkable chains of mountains; being thus the most elevated, in absolute position, as it is supposed to be the lowest in a geological one. It is not, however, limited to such high chains as the Himalaya or the Alps, or even to the much lower ridges of Britain; since it also occupies many extensive tracts of comparatively level land. Hence it presents that diversity of picturesque outline formerly noticed; and if this variety sometimes results from disintegration, the same effects arise from its natural disposition. In these cases it forms tracts of various extent, though often constituting single mountains, or groups, or ridges, far separated from any analogous mass; as it sometimes also occupies places so small as not to be easily discovered."‡

Mr. Strickland, in his Memoir of Geological Investigations in Asia Minor, states—

"He did not observe granite *in situ;* but on the authority of MM. Fontanier, Texier, and other travellers, he believes that it constitutes the highest part of Ida, the Mysian Olympus, the Bithynium Olympus, Mount Diudynius, Mount Timolus, and Mount Latmus. And that the micaceous schists, and associated rocks, occupy a very important place in the geology of Asia Minor, forming nearly all the mountain chains that intersect that country."§

M. de la Beche says, on this subject—

"It must not be inferred, from the small space here dedicated to the inferior stratified rocks, that they are of little importance; for they are found to occupy a large portion of the earth's surface, wherever from denudations and disruptions of strata, or from the original absence of superincumbent rocks, they are exposed to our observation. Wherever observed, whether in Asia, North America, or Europe, they appear with constant general characters."

And a little further on, he adds—"It would be tedious to enumerate the

* Old Red Sandstone, pp. 56, 58.

† Geology, vol. i. pp. 132, 133.

‡ Geology, vol. ii. p. 89.

§ Proceedings of Geological Society, in Literary Gazette, 5th Nov., 1836, p. 714.

various situations where these rocks may be found. It may suffice to state, that there is scarcely any very large extent of country, where from some accident or other they are not exposed on the surface. They abound in Norway, Sweden, and Northern Russia; they are common in the North of Scotland, whence they stretch over into Ireland. In the Alps and other mountains they occupy the central lines of elevation, as if brought to light by the movements which have thrown up the different chains. They abound in the Brazils, and occur extensively in the United States. Our navigators have shown that they are sufficiently common in the various parts of North America visited by them. They are found extensively in the great range of the Himalaya; Ceylon is in a great measure composed of them; and they would not appear to be scarce in various other parts of Asia. And in Africa, also, we know they are not wanting, though but so small a part of that continent has been yet explored with scientific views."*

In further confirmation of the more prominent effects of the centrifugal force, considered by the dynamical theory to have been the cause of the elevation of mountain chains, I shall recapitulate the *twenty-seventh* Theorem, and bring forward some of the evidences on which it rests. That Theorem sets forth, "*That in mountain ranges certain axes of elevation are recognizable, while the outlines of the former frequently assume lengthened, irregular, conical forms, with one or more peaks; whose nucleii and apici usually consist of primary rocks. And that it may be considered as an established fact, both in geology and geography, that these ranges are, in general, comparatively less elevated in extreme latitudes.*"

The following are some of the evidences on which this Theorem is founded:—

Professor Phillips says—

"By a careful study of the circumstances, we observe that these indications of disturbance augment continually toward the axis or centre of the mountain group; and that the direction of the movement has there been upwards. There has, in fact, been a real and violent *elevation* of the stratified crust of the globe, corresponding to the centre or axis of each mountain group," as shown by the diagram which follows† . . . . .

"Cases of *conical elevation* do occur, but rarely: *elliptical* ridges are more frequent; and the centres and axes of such being removed more or less completely, make round or elliptical *valleys of elevation*.

"Hardly any of the lofty mountain ranges on the face of the globe," he continues, "are entirely devoid of *gneiss* and *mica slate* uplifted upon an axis of unstratified granitic masses, so as to be inclined at right angles to the horizon. The great European basin is defined by irregular elevations of this kind from the Frozen Sea to the Atlantic: by the Uralian and Caucasian chains, the ranges of Asia Minor, Greece, South Italy, and the Atlas; the irregular Western Border of Spain, Ireland, the North of Scotland, and Scandinavia is of similar structure."‡

"Mr. Martin," observes Mr. Lyell, "in his work on the Geology of Western Sussex, throws much light on the structure of the Wealden, by

* Manual, pp. 484, 485. † We would beg particular reference to this diagram.
‡ Treatise, pp. 60, 62, 71, 72.

tracing out continuously, for miles, the direction of many anticlinal lines and cross features; and the same course of investigation has been followed out, in greater detail, by Mr. Hopkins. The mathematician last named has shown, that the observed direction of flexure and dislocation in the Weald district coincide with those which might have been anticipated, theoretically, on mechanical principles, if we assume certain simple conditions, under which the strata were lifted up by an expansive subterranean force. He finds, by calculation, that if this force were applied, so as to act uniformly within an elliptic area, the longitudinal fissures thereby produced would nearly coincide with the outlines of the ellipse forming cracks, which are portions of smaller concentric ellipses, parallel to the margin of the larger one. These longitudinal fissures would also be intercepted by others running at right angles to them, and both lines of fracture may have been produced at the same time. In this illustration it is supposed that the expansive force acted simultaneously, and with equal intensity, at every point within the upheaved area, and not with greater energy along the central axis or region of principal elevation. . . . . . This accords well with that expressed by M. Thurnann, in his work on the Anticlinal Ridges and Valleys of Elevation of the Bernese Jura. . . . . . Among other results at which this author arrived, it appears, that the breadth of all the numerous anticlinal ridges and dome-shaped masses in the Jura is invariably great in proportion to the number of the formations exposed to view."*

Professor Phillips gives a parallel passage to that just quoted from Mr. Lyell's work, wherein he, also, relies on Mr. Hopkins's mathematical calculations and conclusions; and being given somewhat more in detail by Mr. Phillips, reference is craved to what is stated by him, although rather long for insertion here; nevertheless, it is considered essential to quote the concluding paragraph:—

"If the approximate accuracy of our assumptions be allowed, as applied to the crust of the globe, it appears from our investigations, that an elevated range, characterized by continuous systems of longitudinal and transverse fissures, referable to the causes to which we have been assigning such phenomena, could not be produced by successive elevations of different points, by the partial action of an elevatory force. In such elevations, fissures would necessarily diverge in all directions from the central points, so that parallel systems, such as have been mentioned above, could not possibly be thus produced. Every system of parallel fissures, in which no two consecutive fissures are remote from each other, must necessarily have had one simultaneous origin."†

And lastly, on this branch of evidence, Mr. Miller, alludes to the same upheaving principle, when describing, with his wonted powers of imagery, some examples in point from the scenes of his geological labours: would that the same clear and comprehensive sketching had been applied to more extended fields of research!

"The natural boundaries of the geographer," says he, "are rarely described by right lines. Wherever these occur, however, the geologist may look for something remarkable. There is one very striking example

* Elements, vol. ii. pp. 28—30, and the authorities there given.
† Treatise, pp. 266—270.

furnished by the North of Scotland. The reader, in consulting a map of the kingdom, will find that the edge of a ruler laid athwart the country, in a direction from south-west to north-east, touches the whole northern side of the great Caledonian valley, with its long straight line of lakes; and onwards beyond the valley's termination at both ends, the whole side of Loch Eil and Loch Linnhe, and the whole of the abrupt and precipitous northern shores of the Moray Frith, to the extreme point of Tarbat Ness; a right line of considerably more than a hundred miles. Nor does the geography of the globe furnish a line better defined by natural marks. There is both rampart and fosse. On the one hand we have the rectilinear lochs and lakes, with an average profundity of depth more than equal to that of the German Ocean, and, added to these, the rectilinear lines of frith; on the other hand, with but few interruptions, there is an inclined wall of rock, which rises at a steep angle in the interior to nearly two thousand feet over the level of the great canal, and overhangs the sea towards its northern termination, in precipices of more than a hundred yards.

"The direction of this rampart and fosse, this Roman wall of Scottish geological history, seems to have been that in which the volcanic agencies chiefly operated in upheaving the entire island from the abyss. The line survives as a sort of foot-track, hollowed by the frequent tread of earthquakes, to mark the course they journeyed. Like one of the great lines in a trigonometrical survey, it enables us, too, to describe the lesser lines, and to determine their average bearing. *The volcanic agencies must have extended athwart the country from south-west to north-east.* . . . . . . In all these lines, whether of mountains, lakes, friths, or formations, there is an approximation to parallelism with the line of the great Caledonian Valley; proofs that the upheaving agency from beneath must have acted in this direction from some unknown cause, during all the immensely extended term of its operations, and along the entire length of the island.*

To prove that mountains and mountainous chains are, generally, more elevated the nearer they are to the equatorial region, I advert to the testimony afforded by the various graduated scales, or synoptic views of the most noted mountains of the world, and, also, to the following more general evidence, which incidentally occur in scientific works.

"It is well known," says the accomplished author of *The Connexion of the Sciences*, "that the continents at the equator are more elevated than they are in higher latitudes."†

Professor Phillips, when endeavouring to disprove the assumption, that the globe might, by natural changes, be worn down by rains and waves, from a perfect sphere to a spheroid of rotation, after showing what would, under such a state of matters have been the case near to the equator, goes on to say:—

"But nothing of the kind appears; on the contrary, the distribution of land and water is excessively irregular, &c.; and the equatorial regions *include some of the highest mountains on the globe.*"‡

* Old Red Sandstone, pp. 137, 138. † Page 56.
‡ Treatise, pp. 7, 8, which please see.

What has hitherto been brought forward refers to *external* appearances only; to prove by *them*, as far as they are available, that the mountain chains owe their elevation to the protorotation of the earth, and its dynamical consequences; and certainly, when the evidences which have been adduced from geological writers are compared with the effects anticipated from the dynamical force, engendered by the first diurnal revolution of the earth, upon the concentric rocky masses of the primitive sphere, we are borne out in maintaining, that this external branch of the evidence goes a great way towards proving, that the peculiar structure of the mineral crust of the earth is due to that cause. But I must now proceed, in further support of the same position, to carry the investigations into *the more intimate formation* of those mountains, and into the *mineralogical structure* of the rocks which compose them. To effect this, I shall commence by adducing *the reasons which exist for supposing, that the rocks of which they are composed have been moved en masse from the positions wherein they were originally formed.* In consequence of the simplicity and homogenity of the mineralogical composition, as well as the amorphous nature of the unstratified rocks, they do not, of themselves, present a sufficient prominency of character, on which to raise a conclusive chain of reasoning; but, fortunately, this difficulty is removed when the enquiry is directed to those stratified masses which immediately rest upon or overlie them; and with whose elevation they are so intimately associated that, by their means, we can reason regarding the primary rocks with a degree of certainty which banishes all doubt from the mind.

By the *fourteenth* Theorem it will be seen, "*That the stratified rocks afford sufficient evidence of having been formed in succession, horizontally and tranquilly by deposition from water; although, in many instances, bearing marks of the water having been gently undulated. That they differ in many respects from the primary amorphous masses.*" The concluding term of this Theorem being irrelevant, it is not recapitulated.

The evidences on which these opinions rest being of importance to the future argument, several of them will be given at some length.

"Stratified rocks," says Dr. M'Culloch, "have been deposited from water. They have been produced from fragments, or from dissolved substances, or from both. They have been consolidated by mechanical forces, or by chemical actions, or by both. They were once horizontal in position, or nearly so, and their positions are now various. They were once continuous and straight planes, or nearly so, as far as their extent; and they are now bent, fractured, and separated. They were once unmixed with unstratified rocks, and they are now intermixed with them. They were once, or oftener, below water, and they are now above it. They are repeated in consecutive and parallel order of the same, or different kinds. With rare exceptions, every stratum is of later origin than the one next below it. . . . . .

"The term stratum, or bed, carries its own definition with it; its extent,

according to the prolongation of its great opposing planes, being generally far greater than its thickness. A repetition of such beds forms a series of strata; and the term stratification implies the mode of their deposition, to whatever cause that may be attributed. The term stratification therefore implies a cause as well as a mode of form and disposition; and that cause is assumed or proved to consist in a deposition from water, of materials that have been suspended and dissolved in it."*

"The aqueous rocks," observes Mr. Lyell, "sometimes called the sedimentary, or fossiliferous, cover a larger part of the earth's surface than any others. These rocks are stratified, or divided into distinct layers or strata. . . . . .

"Fossil shells of forms, such as now abound in the sea, are met with far inland, both near the surface and at a great depth below it. They occur at all heights above the level of the ocean, having been observed at an elevation of from 8,000 to 9,000 feet in the Alps and Pyrenees, of more than 13,000 feet in the Andes, and above 16,000 feet in the Himalayas. (Geogr. Journal, vol. iv. p. 64.) These shells belong mostly to marine testaceæ, but in some places exclusively to forms characteristic of lakes and rivers. Hence it is concluded that some ancient strata were deposited at the bottom of the sea, and others in lakes and estuaries. . . . . .

"We have now pointed out one great class of rocks, which, however they may vary in mineral composition, colour, grain, or other characters, external and internal, may, nevertheless, be grouped together as having a common origin. They have all been formed under water, in the same manner as accumulations of sand, mud, shingle, banks of shells, reefs of coral, and the like, and are all characterized by stratification or fossils, or by both."

And again—

"Before entering into a more detailed investigation of the stratified rocks, it will be advisable to say something of the ordinary materials of which such strata are composed. These may be said to belong principally to three divisions, the arenaceous, the argillaceous, and the calcareous, which are formed respectively of sand, clay, and carbonate of lime. Of these, the sandy masses are chiefly made up of siliceous or flinty grains. The clayey, of a mixture of siliceous matter, with usually about one-fourth in weight of aluminous earth, and, lastly, the limestone or calcareous rocks consist of carbonic acid and lime.

"It has generally been said, that the upper and under surfaces of strata, or the planes of stratification are parallel. Although this is not strictly true, they make an approach to parallelism, for the same reason that sediment is usually deposited, at first, in nearly horizontal layers.

"The *ripple mark* so common on the surface of sandstones of all ages, seems to have originated in the drifting of materials along the bottom of the water in a manner very similar to that which may explain the inclined layers above described. This ripple is not entirely confined to the beach between high and low water marks, but is also produced on sands which are constantly covered by water."†

And, finally, from this author—

* Geology, vol. i. pp. 12, 67.

† Please refer to the diagram given at this place in Mr. Lyell's work.

"In short, the universal fluidity of the crystaline formations of the earth's crust, can only be understood in the same sense as the universality of the ancient ocean. All the land has been under water, but not all at one time; so all the subterranean unstratified rocks to which man can obtain access have been melted, but not simultaneously."*

Dr. Buckland says—

"A great majority of the strata having been formed under water, and from materials in such a state as to subject their arrangement to the operation of the laws of gravitation; had no disturbing force interposed, they must have formed layers almost regularly horizontal, and therefore investing in concentric coats the nucleus of the earth, ... in which case we should have wanted that variety of useful minerals almost indispensable to the existence of man in a state of civil society, which this succession of different strata, by their partial verticality, now present to us."†

Professor Phillips thus expresses himself on the same subject:—

"The essential principles admitted by both of these eminent men (Werner and Smith) are very simple; they affirm that the materials in the crust succeed one another in a particular order or series. This is nothing more than asserting generally, what is, in very many instances, found to be true locally, by the experience of miners, colliers, well-sinkers, quarrymen, and others."

Again, after enumerating in detail the several descriptions of stratified rocks, he adds—

"And under these is granite, which nowhere appears to be stratified.

"Thus we have two classes of rocks, stratified and unstratified, which will require distinct examination.

"In each of the localities specified, the series of strata is found to be constant, not that every particular stratum is everywhere observed; but the *order in which they succeed one another, when present together, is never reversed.* This is consistent with all experience."

And in conclusion from this scientific writer—

"The true scale of geological chronology is that of the stratified rocks. According to the view previously advocated, the several systems of strata mark periods more or less exactly definable; the last, or supertertiary, which descends to the present era of the globe, being, as yet, one of the least defined in its limits. . . . . .

"At present, the chronology of the globe, starting from the origin of the stratified rocks, and including the whole series of successions of organic beings, and all the convulsive disturbances of the cooled and consolidated crust, recognises many successive periods of unknown duration. Neither does it appear possible to know their duration, or even the limits of error within which they fall. How, then, it may be asked, do geologists justify their confident assertions of the very great antiquity of particular rocks, as compared with the few thousand years of history? To this the reply is simple. Many of the ancient stratified rocks were formed in the sea, by

* Although we differ in our conclusions, yet I give these passages on account of the evidences they afford in favour of the point I am endeavouring to substantiate at present.

† Vindicæ Geologicæ, pp. 11, 12.

processes perfectly similar to those which go on at this day; and, *in some cases*, we may believe not at all more rapid in their effects.

"The laminated sandstones often mark what appears to be the ripple of a gentle tide, and the successive deposits of agitated water; the shelly limestones sometimes prove very slow deposition of even a single layer of calcareous rock; the alternation of igneous and sedimentary rocks gives us the similitude of volcanic submarine eruptions. Now, if we compare, with the sedimentary strata of any particular period, the most similar products of the present day, we shall be impressed with the necessity of allowing a long period for the production of a single stratified formation."*

M. de la Beche says—

"In the accompanying table, rocks are first divided into stratified and unstratified, a natural division, or, at all events, one convenient for practical purposes.

"The same may, perhaps, also be said of the next great division; namely, that of the stratified rocks into superior, or fossiliferous, and inferior, or non-fossiliferous. The superior stratified, or fossiliferous rocks are divided into nine groups.

"In a descending series these are:—1. *Modern;* 2. *Erratic Block* Group; 3. *Supra-cretaceous;* 4. *Cretaceous;* 5. *Oolitic;* 6. *Red Sandstone;* 7. *Carboniferous;* 8. *Grauwacke; and* 9. *Lower Fossiliferous;* and underneath them all, the *Inferior or Non-fossiliferous* strata."†

M. de la Beche's work, from its design being necessarily descriptive, should any one desire fuller information from that correct geologist, his work itself will require to be perused, as the stratified rocks and their embedded fossils occupy nearly the whole treatise.

With these facts, obtained from so many unquestionable authorities, fresh upon the mind, let us recur to what is stated in the *seventeenth* Theorem.

"*That, from the evidence afforded by the position and dislocation of the stratified masses, it is considered, that they have been elevated from where they were originally deposited, into the inclined positions they now occupy; and by the agency of a force which acted from below upwards. And, that the time occupied in their elevation was very brief comparatively with that which elapsed during their formation.*"

The following are some of the evidences for these opinions:—

Mr. Lyell boldly commences—

"LAND *has been raised, not the sea lowered.* It has already been stated, that the aqueous rocks, containing marine fossils, extend over wide continental tracts, and are seen in mountain chains rising to great heights above the level of the sea. Hence it follows, that what is now dry land was once under water. But if we admit this conclusion, we must imagine either that there has been a general lowering of the waters of the ocean, or, that the solid rocks, once covered by water, have been raised up bodily out of the sea, and have thus become dry land. The earlier geologists embraced the former opinion, assuming that the ocean was originally universal, and

* Treatise on Geology, pp. 30—33, 291, 292.

† Manual, pp. 34—37.

had gradually sunk down to its actual level, so that the present islands and continents were left dry."

After enumerating the difficulties in which this involved them, Mr. Lyell goes on to say—

"Geologists, therefore, were at last compelled to have recourse to the other alternative, viz., the doctrine that the solid land has been repeatedly* moved upwards or downwards, so as permanently to change its position relatively to the sea. . . . . These preliminary remarks will prepare the reader to understand the great theoretical interest attached to all facts connected with the position of strata, whether horizontal or inclined, curved or vertical. . . . . The most unequivocal evidence of a change in the original position of strata is afforded by their standing up perpendicularly on their edges, which is by no means a rare phenomena, especially in mountainous countries. . . . . . Vertical strata, when they can be traced continuously upwards or downwards for some depth, are almost invariably seen to be parts of great curves, which may have a diameter of a few yards, or of several miles.

"I may now recapitulate a few of the conclusions to which we have arrived. The dry land consists, in a great part, of strata formed originally at the bottom of the sea, and has been made to arrange and attain its present height by a force acting from beneath."

And in conclusion, from Mr. Lyell, he continues, towards the end of his work—

"If we admit that solid hypogene rocks, whether stratified or unstratified, have in such cases been driven upwards, so as to pierce through yielding sedimentary deposits, we shall be enabled to account for many geological appearences otherwise inexplicable."†

Professor Buckland says—

"The actual position of these beds (the stratified masses of rock) is generally more or less inclined to the horizontal plane, though often under an angle almost imperceptible. By this arrangement many strata, affording numerous varieties of mineral productions, are made to emerge in succession on the surface of the earth."‡

Professor Phillips asserts—

"We are fully convinced, that for broad and extensive formations of strata, composed of various successions of sands, clays, and limestones, variously stored with organic remains, there can be no risk of error in assuming, as a fact sufficiently proved, that they were deposited nearly level. Assured of this fact, as a basis of reasoning, we may proceed to enquire into the actual position of strata, as they are seen in the dessicated parts of the old oceanic bed which now compose our solid land. The most general condition of the stratified rocks of all ages is to be *not quite level*, but inclined to the horizon in some one direction, and at some certain angle, in each locality. . . . .

"By a careful study of the circumstances, we observe, that these indica-

* This, of course, I dissent from.
† Elements, vol. i. pp. 94—96, 101, 102, 146, 147. Vol. ii. pp. 370, 371.
‡ Vindic. Geol. p. 11.

tions of disturbances augment continually towards the axis or centre of the mountain group; and that the direction of the movements has been there upwards. There has, in fact, been a real and violent *elevation* of the stratified crust of the globe, corresponding to the centre or axis of each mountain group. . . . . .

"We are thus led to associate the phenomena of the disturbance of strata with the eruption of crystalized rock from beneath. The latter, however, is not the cause of the former, but rather a concomitant effect of some general dynamical agency."*

Professor Playfair, in his Illustrations of Hutton's Geological Theory, gives the following graphic passage:—

"We have seen," says he, "of what material the strata are composed, and by what power they have been consolidated; we are next to enquire from what cause it proceeds, that they are now so far removed from the region which they originally occupied, and wherefore, from being all covered by the ocean, they are at present raised, in many places, 15,000ft. above its surface. It is certain that many of the strata have been moved angularly, because that, in their original position, they must have been all nearly horizontal. Loose materials, such as sand and gravel, subsiding at the bottom of the sea, and having their interstices filled with water, possess a kind of fluidity; they are disposed to yield on the side opposite to that where the pressure is greatest, and are, therefore, in some degree, subject to the laws of hydrostatics. On this account they will arrange themselves in horizontal layers; and the vibrations of the incumbent fluid, by impressing a slight motion backward and forward, on the materials of these layers, will very much assist the accuracy of their level. Now rocks, having their layers exactly parallel, are very common, and prove their original horizontality to have been more precise than we could venture to conclude from analogy alone. This horizontality could only be produced by those laminæ having been originally spread out on a flat and level surface, from which situation, therefore, they must afterwards have been lifted up by the action of some powerful cause, and must have suffered this disturbance while they were yet, in a certain degree, flexible and ductile. Though the primary direction of the force which thus elevated them must have been from below upwards, yet it has been so combined with the gravity and resistance of the mass to which it was applied, as to create a lateral and oblique thrust, and to produce those contortions of the strata, which, when on the great scale, are among the most striking and instructive phenomena of geology. Great additional force is given to this argument, in many cases, by the nature of the materials of which the stratified rocks are composed. The beds of breccia and puddingstone, for instance, are often in planes almost vertical, and, at the same time, contain gravel-stones, and other fragments of rock, of such a size and weight, that they could not remain in their present position an instant, if the cement which unites them were to become soft; and therefore they certainly had not that position at the time when this cement was actually soft. Nothing can be more sound and conclusive than this reasoning. If some of the vertical strata are proved to have been formed horizontally, there can be no reason for not extending the same conclusion to them all, even if we had not the support of the argument from the parallelism

* Treatise, pp. 59—61, 98.

of the layers, which has been already stated. The highly inclined position and the manifold inflections of the strata, are not the only proofs of the disturbance that they have suffered, and of the violence with which they have been forced up from their original place. Those interruptions of their continuity which are observed, both at the surface and under it, are evidences of the same fact. It is plain, that if they remained now in the situation in which they were at first deposited, they would never appear to be suddenly broken off. No stratum would terminate abruptly; but however its nature and properties might change, it would constitute an entire and continued rock. There are, however, instances of a breach of continuity in the strata, under the surface, that afford a proof of the violence with which they have been displaced, different from any hitherto mentioned. Of this nature are the *slips* or *shifts*, that so often perplex the miner in his subterraneous journey. . . . . . The strata on one side of the *slip* continue parallel to those on the other; in other cases, the strata on each side become inclined to one another, though their identity is still to be recognized by their possessing the same thickness, and the same internal characters. All these are the undeniable effects of some great convulsion, which has shaken the very foundations of the earth; but which, far from being a disorder in nature, is part of a regular system, essential to the constitution and economy of the globe. . . . . .

"Though such marks of violence as have been now enumerated are common, in some degree, to all strata, they abound most among the primary, and point out these as the part of our globe which has been exposed to the greatest vicissitudes. At their junction with the secondary, phenomena occur, which mark some of the vicissitudes with astonishing precision; and from which Mr. Hutton concluded, that the primary strata, after having been formed at the bottom of the sea, in planes nearly horizontal, were raised, so as to become almost vertical, while they were yet covered by the ocean, and before the secondary strata had begun to be deposited upon them. . . . . .

"And on the whole, therefore, by comparing the actual position of the strata, their erectness, their curvature, the interruptions of their continuity, and the transverse stratification of the secondary in respect to the primary, with the regular and level situation which the same strata must have originally possessed, we have a complete demonstration of their having been disturbed, torn asunder, and moved angularly, by a force that has, in general, been directed from below upwards."*

Sir John Herschel bears testimony to the same effect, when he thus expresses himself—

"Many of the strata, which thus bear evident marks of having been deposited at the bottom of the sea, and, of course, in a horizontal state, are now found in a position highly inclined to the horizon, and even occasionally vertical. And they often bear evident marks of violence, in their bending and fracture, in the dislocation of parts which were once contiguous, and in the existence of vast collections of broken fragments, which afford every proof of great violence having been used in accomplishing some, at least, of the changes which have taken place."†

* Playfair's Illustrations of the Huttonian Theory, vol. i. pp. 56—67.
† Discourse on Natural History, Cab. Cyc. p. 284.

Mr. Ansted seems to be convinced of the presence of a very powerful elevating agency, acting from beneath, for he thus appropriately describes the symptoms of violent commotion and movement which took place amongst the mineral masses, belonging to what he designates his first and second epochs :—

"But a time of much greater change was approaching, a time of disturbance, which should shake to their foundations all the solid and massive rocks that had been then deposited; and of subterranean movements, which, in their course, should break asunder the hardest and the strongest among these rocks; crushing and grinding, into small fragments, whole strata, that had become compact and closely consolidated, and crumpling, into complicated folds, the toughest and most unyielding beds, as if they had been layers of some soft material, carelessly squeezed in the grasp of a powerful hand.

"It is, indeed, impossible for words to express the complication of disturbance, or the amount of confusion, that has been produced, in some districts, by forces acting on the solid crust of the globe, between the close of what we have called the first epoch, and the commencement of the second; and yet all this was done with a certain degree of order, and doubtless occupied a long period of time.* Volcanic eruptions have taken place in some districts, and their effect is seen in torrents of ancient lava, heaps of erupted ashes, and rocks chemically changed, by the intrusion of heated vapours charged with gases. In others, enormous cracks, extending for many hundred yards, or even for miles together, may be traced in the more brittle rocks; and the rocks themselves have been burnt, as in a furnace, by the boiling and bubbling mass of molten lava, which has been poured from beneath into such wide fissures. Sometimes extensive tracts, where the rocks are thinner and tougher, have exhibited these cracks, in systems of hundreds in number, parallel to one another; while here and there the intense fiery action from beneath has thrown up the surface into blisters and domes, which are often fractured at the top, and thus reveal the history of their elevation. Still more frequently, also, the irresistible subterranean force has snapped asunder the strata, as a violent blow would pierce through a few folds of paper, and one side of the broken bed has been lifted high in the air, or sunk into a deep hollow beneath. And if, as happened occasionally, the force was not sufficiently energetic to break up in this way the whole group of overlying matter, it might yet effect a no less striking result, raising up the strata upon a line, or on a point, and producing a saddle-shaped or a dome-like elevation, according to the circumstances of the case. All these effects, and all of them on the grandest scale, were produced in some way or other upon many of the old rocks towards the close of the first epoch of creation; and every geologist, familiar with the structure of our own island, could readily point to abundant examples of each particular disturbance above alluded to. Every coal-field is so split asunder and broken into small fragments by what are called "faults" (cracks and consequent disturbances of the strata) that they alone might be appealed to as

* The tenor of all my arguments will show, that I feel disposed to express this idea as to the evidence "of a long period of time" having elapsed, in a very different way from Mr. Ansted. A "long period" certainly did elapse, but it was *in the formation of the materials* of which these rocks are composed; the *time* occupied in elevating and transforming them into their present sites and actual condition, it is considered did not exceed twenty-four hours common time.—Author.

sufficient proof. It is not unlikely that much of the general contour of the high ground of England, and many parts of Northern Europe, was originally marked out during the restless disturbances of this interval of violence. And there cannot be a question as to the intensity and continuance of the forces acting beneath the surface, at that time, having been then much greater than any that have since affected that portion of the earth's crust exposed for investigation in our own island."*

Mr. Miller, when describing the upheaved position of the strata in the Great Caledonian Valley, thus expresses himself—

"The north-eastern portion of this rectilinear wall or chain runs, for about thirty miles, through an old red sandstone district. The materials which compose it are as unlike those of the plain out of which it arises, as the materials of a stone dyke, running half-way into a field, are unlike the vegetable mould which forms the field's surface. The ridge itself is of a granitic texture—a true gneiss. At its base we find only conglomerates, sandstones, shales, and stratified clays, and these lying against it in very high angles. Hence the geological interest of this lower portion of the wall. Imagine a large wedge forced from below through a sheet of thick ice on a river or pond. First the ice rises in an angle, that becomes sharper and higher as the wedge rises; then it cracks and opens, presenting its up-turned edges on both sides, and through comes the wedge. And this is a very different process, be it observed, from what takes place when the ice merely cracks, and the water issues through the crack. In the one case there is a rent and water diffused over the surface, in the other there is the projecting wedge, flanked by the upturned edges of the ice; and these edges of course serve as indices to decide regarding the ice's thickness, and the various layers of which it is composed. Now, such are the phenomena exhibited by the wedge-like granitic ridge. The lower red sandstone, tilted up against it on both sides at angles of about eighty, exhibits in some parts a section of well-nigh two thousand feet stretching from the lower conglomerate to the soft unfossiliferous sandstone, which forms, in Ross and Cromarty, the upper beds of the formation. There is a mighty advantage to the geologist in this arrangement. When books are packed up in a deep box or chest, we have to raise the upper tier ere we can see the tier below, and this second tier ere we can arrive at a third, and so on to the bottom. But when well arranged on the shelves of a library, we have merely to run the eye along their lettered backs, and we can thus form an acquaintance with them at a glance, which in the other case would have cost us a good deal of trouble.

"Now, in the neighbourhood of this granitic wedge, or wall, the strata are arranged, not like books in a box—such was their original position—but like books on the shelves of a library. They have been unpacked and arranged by the uplifting agent; and the knowledge of them, which could only have been attained, in their first circumstances, by perforating them with a shaft of immense depth, may now be enquired simply by passing over their edges.

A morning's saunter gives us what would have cost, but for the upheaving granite, the labour of a hundred miners for five years."†

"If the highly inclined position of the strata," says Dr. McCulloch,

* Ancient World, London, 1847, pp. 106—108.

† Old Red Sandstone, pp. 139—141.

"were not in itself a proof of their elevation, evidences of motion are found in a great number of phenomena. In their curvatures we find proofs of disturbance; we find even more decided evidence to the same purpose in their fractures. But when we see that these fractures are often accompanied by a separation of the parts which were once continuous, that one portion of a stratum occupies a higher or a lower place than another, and that this separation is often attended by a difference in the angle of inclination of the separated parts, we have every proof than can be desired, of an alteration in the positions of stratified rocks since the period at which they were formed or consolidated. . . . . . It is well known that certain marine worms which live in sand, and which inhabit straight tubular shells, invariably penetrate the sand in a vertical direction. Analogous fossils found in the horizontal strata, preserve the same vertical position. But where such strata are inclined, the position of the animal is no longer vertical to the horizon, although it preserves its perpendicular position to the stratum; indicating the change of place which that has undergone since it formed a part of the ocean's bed. The same conclusion follows, from considering the positions of leaves in the strata that accompany coal. In these cases, the flat side of the leaf is inavariably parallel to the plain of the stratum, although it may often be vertical to the horizon; a position, it is sufficiently plain, in which such substances could not have been deposited from water. The general elevation of strata from the bottom of the ocean being thus proved, it remains to enquire," &c. &c.*

These numerous and concurring evidences, to which may be added, with perhaps equally convincing effect, the sectional drawings of suits of formations on Mr. Knipe's geological map of the British Islands, exhibiting at a view, and in the most faithful manner, the effects of the elevating power upon the stratified formations, will sufficiently testify that the *stratified* masses are considered *to have been moved* from the horizontal posture in which they were deposited, to the elevated positions they now occupy, by a force which acted *from below upwards.* And as they repose on the *unstratified rocks,* it follows, as an axiom, *that the latter must likewise have been moved from where they were formed, before those which overlie them could have been elevated by a force acting in the direction just mentioned.* This direction *from below upwards,* coinciding precisely with that of the centrifugal impetus—originating from rotation—which would necessarily be impressed on these associated masses, which remained at rest as long as the earth had not been caused to revolve around its axis, it is claimed as its just privilege; *that the dynamical force thus engendered may, for the present, be allowed a place amongst those which are considered competent to have occasioned the removal of the concentric mineral masses from the recumbent posture in which they were formed, to the elevated positions they now occupy;* and in the sequel proof will be brought forward to show, that *to this force exclusively must be attributed that stupendous result,* and whose successful establishment will prepare the way for clearing up other points from their present uncertainty.

* Geology, vol. i. pp. 88—90.

SECTION V.

GEOLOGICAL PHENOMENA RESULTING FROM THE EARTH'S PROTOROTATION.

CHAPTER XX.

Evidences to prove, that the non-rotatory sphere was circumbounded by water—astronomical proof—geological proof. This fact, combined with what was established in previous chapters, leads to the conclusion, that violent movement, therefore much friction, and consequently great heat, would necessarily ensue amongst the rocky masses of the earth's crust. The characteristics of Friction enquired into, and the Breccia which would result, when mineral formations, abounding with calcareous material, were subjected to its influence under water. The great Breccia and Conglomerate formations geologically described, and shown to correspond with that which the Dynamical Theory requires for its perfection should be found to exist. Some of the more special uses which they were designed to accomplish made manifest. The Coal Measures protected by the Conglomerate and Breccia from fusion and denudation The nucleii of mountain ranges the resultant foci of heat engendered by friction. Geological proof of this, deduced alike from the mineralogical structure of the rocks composing these elevations, and from the existing symptoms of fusion, evidenced by the altered condition of their contiguous strata.

THE several subjects which the successful issue of the argument in the last chapter enables us now to investigate, though numerous, are all equally worthy of notice, while they simultaneously press upon the attention; but I shall follow what may be considered to have been their sequence in the order of time, by endeavouring to prove, first, *that the primeval world was enveloped by an illimitable ocean, under whose atmosphereless waters the elevating revolution just established took place.* With this view I shall begin by recurring to the *tenth* Theorem, which states—"*That according to investigations made by M. de la Place, for the purpose of demonstrating the stability of the equilibrium of the sea, it has been discovered, that the equilibrium of the sea must be stable, and its oscillations continually tending to diminish, if the density of its waters be less than the mean density of the earth; and that its equilibrium would not admit of subversion, unless the mean density of the earth was equal to that of water or less.*"

Looking more minutely into the evidences which warrant this

general assertion, Professor Playfair is found thus expressing himself—

"La Place has treated a subject connected with the tides, that, so far as we know, has not been entered upon by any author before him. This is the stability of the equilibrium of the sea. A fluid surrounding a solid nucleus may either be so attracted to that nucleus, that when any motion is communicated to it, it will oscillate backwards and forwards till its motion is destroyed by the resistance it meets with, when it will again settle into rest; or it may be in such a state, that when any motion is communicated to it, its vibrations may increase, and become of enormous magnitude. Whether the sea may not, by such means, have arisen above the tops of the highest mountains, deserves to be considered; as that hypothesis, were it found to be consistent with the laws of nature, would serve to explain many of the phenomena of natural history. La Place, with this view, has enquired into the nature of the equilibrium of the sea, or into the possibility of such vast undulations being propagated through it. The result is, that the equilibrium of the sea must be stable, and its oscillations continually tending to diminish if the density of its waters be less then the mean density of the earth; and that its equilibrium does not admit of subversion, unless the mean density of the earth was equal to that of water, or less. As we know, from the experiments made on the attraction of mountains, as well as from other facts, that the sea is more than four times less dense than the materials which compose the solid nucleus of the globe are at a medium,* the possibility of these great undulations is entirely excluded; and, therefore, says La Place, if, as cannot well be questioned, the sea has formerly covered continents that are now much elevated above its level, the cause must be sought for elsewhere than in the instability of its equilibrium."†

Mrs. Somerville confirms this when she asserts that—

"It is also necessary for the equilibrium of the ocean, that its density should be less than the mean density of the earth, otherwise the continents would be perpetually liable to inundations from storms and other causes."

And again—

"One of the most remarkable circumstances in the theory of the tides is the assurance that, in consequence of the density of the sea being only one-fifth of the mean density of the earth, and the earth itself increasing in density towards the centre, the stability of the equilibrium of the ocean can never be subverted by any physical cause. A general inundation arising from the mere instability of the ocean, is, therefore, impossible."‡

While the impressions arising from these evidences are vividly on the mind, should reference be again made to the *thirteenth* Theorem, it will be found therein recorded, in conformity with this opinion of M. de la Place himself, and on the authority of a host of other witnesses, whose testimony cannot possibly be set aside, "*That wherever any considerable portion of the earth's surface has been examined by*

* Confirmed by the *eighth* Theorem.
† Playfair's Works, vol. iv. pp. 302—305.
‡ Connexion of the Sciences, pp. 56, 114.

*geologists, it has invariably afforded proofs of having been, at one time, submerged in the waters of the ocean."**

This evidence, certainly, appears to be very perplexing, when we take into account what has just been established, with respect to the equilibrium of the ocean, and the impossibility of its overflowing the land, as the two are at present constituted. It places us, as well as M. de la Place, in a dilemma, from which we can be extricated only by one of the two following conclusions; either that those portions of the earth—and it must be remembered they embrace parts of its whole surface—which afford such unequivocal symptoms of having been formerly submerged in the ocean, *have risen above it in detached portions, at different periods*, whilst corresponding depressions of surface took place in other localities. Or, that they were *all synchronously elevated and depressed, as the effects of one great and general revolution, while as yet the earth was surrounded by the primeval ocean.*

Leaving the supporters of the former opinion to bring forward their evidence at leisure, without adding to their difficulties by a single observation; I implicitly rely on the well-grounded assumption, that every succeeding fact which may be brought to light, will tend further to corroborate the opinion maintained in this theory, namely, *that there was only one general elevation of the continents and mountains of the world; and one simultaneous depression of its ocean beds and valleys; being the first and most important results of the centrifugal force, occasioned by the earth's protorotation*, and which, in turn, was caused by the formation of the light, and its division from the darkness—positions which every successive step in the progress of this work will render more and more apparent and convincing. It is repeated, therefore, *that there was only one general formation of continents and mountains, with their corresponding oceanic hollows and valleys on the face of the globe we inhabit; and that this took place on the first day of the Mosaic week.* It is hoped that in due time both of these positions will be proven; thereby leading to the undeniable conclusion, *that previously to these elevations and depressions, the whole surface of the earth was synchronously submerged in the water of the primitive ocean.* To this conclusion the DYNAMICAL Theory leads us. The same final result may, I think, be come to by impartially comparing the opinions given by geologists who have directed their attention to points connected with the Dynamical branch of their researches. Some of these conclusions have already been given, but are repeated here, as they, likewise, afford evidence on the question more immediately under consideration. Professor Phillips says—

"Over immense tracts of the earth's surface, the angle of inclination is extremely moderate; more than three-fourths of the surface of Europe (and probably of other continents) is occupied by strata, which in common language may be said to be nearly horizontal. . . . . . Among the Alps and

* It will be remembered that, in a previous part of this Treatise, the evidences pertaining to this Theorem were adduced, consequently they are not here recapitulated.

Pyrenees, the strata, which in every part of their surface were originally very little inclined, and which at a distance from the mountains retain nearly their original position, are thrown into various disturbed positions; the local effect of violent convulsions. By a careful study of the circumstances we observe that these indications of disturbance augment continually towards the axis or centre of the mountain group; and that the direction of the movements has been there upwards. There has, in fact, been a real and violent *elevation* of the stratified crust of the globe, corresponding to the centre or axis of each mountain group."* . . . . .

"We are thus led," he continues, a little further on, "to associate the phenomena of the disturbances of the strata with the eruption of crystalized rock from beneath; but the latter is not exactly the *cause* of the former, but rather a concomitant effect of some general dynamical agency. . . . . . Once acquainted with this relation of the two classes of rocks, we are in possession of a clue to guide us through all the mazes of local geology; for it is equally true of small elevations of strata, as of all mountain chains, that the most general condition observable is the mutual dependence of these disturbances, and the eruptions of unstratified rocks."†

The whole tenor of these passages clearly indicates, that while the elevations of these centres or axes of elevation have been the immediate cause of the *alteration* and *disturbance* of the once horizontal strata, they were themselves impelled to become so, as the co-effect of some general and deep-seated force which occasioned them to protrude, and in doing so, to elevate and to disturb the once superincumbent stratiform masses, and that this may be considered as a general rule, applicable to the whole surface of the earth, wherever mineral masses are found disturbed and elevated.

Then, from an entirely different source—the result of dexterously applied mathematical investigation to the probable origin of the inequalities of the earth's mineral crust—we have a remarkable corroboration of the same views; with the addition, that this method seems to repudiate the possibility of "an elevated range, characterized by continuous systems of longitudinal and transverse fissures being produced by successive elevations of different points, by the partial action of an elevatory force;" but that "every system of parallel fissures, in which no two consecutive fissures are remote from each other, must necessarily have had a simultaneous origin."‡

To these two sources of evidence, which prove, that throughout the whole terraine surface, disturbances of the starta may be considered to be intimately associated with the irruptions of unstratified rocks; and that "continuous systems must have had a simultaneous origin;" there may be added, the late hypothesis of M. Elie de Beaumont, by which the principal mountain chains throughout the world are grouped into systems, each supposed to have "a common origin," and some of which embrace a vast extent of geographical area; for instance—

* This he illustrates by a diagram, which it would be well to consult.

† Pages 60, 61.

‡ Phillips, p. 270, from Mr. Hopkins's calculations.

"M. de Beaumont," says Professor Phillips, "assigns to this period (that of the *cretaceous* system) his Pyreneo-Apennine system of convulsion, the elevation of the Pyrenees, Carpathians, Northern Apennines, Dalmatia, and the Morea, in lines ranging parallel to a great circle on the sphere, through Natchez on the Mississippi, and the Persian Gulf. It appears, also, that some disturbances, which happened during the cretaceous era, are traceable in Mont Viso and the Western Alps."*

The latest digest of the opinion of those who have paid most attention to this interesting and much-debated dynamical question, has been given to the public in the following Inaugural Address of Professor Hopkins, at the Meeting, in Hull, of the British Association, and merits special attention, when it is considered how much attention he himself has given to this particular department of geological research :—

"The dynamical, or, more strictly, the mechanical department of geology, has received a much larger share of attention. In fact, almost all theories and speculations of geologists, independently of organic remains, belong to it, and a large portion of the work of geologists in the field has been devoted to the observation of phenomena on which it treats. *Phenomena of elevation,* those which have immediately resulted from the action of the subterranean forces which have so wonderfully scarred and furrowed the face of our globe, have been made the objects of careful research. It is to this probably violent and desolating action that we owe the accessibility of the the mineral sources of our mining districts, as well as all those exquisite beauties of external nature which the mountain and the valley present to us. The absence of all order and arrangement would seem, on a superficial view, to be the especial characteristic of mountainous districts; and yet the nice observations of the geologist have detected in such districts, distinct approximations to general laws, in the great dislocations and upheavals in which the mountains and the valleys have originated. The more usual law in these phenomena consists in the approximate parallelism of all those great lines of dislocation and chains of mountains, the formation of which can be traced back to the same geological epoch. That this law is distinctly recognisable throughout districts, sometimes of many hundred miles in extent, is clearly established; but some geologists contend that it may also be recognised as prevailing over much larger geographical areas than any single geological district presents to us. M. Elie de Beaumont was the originator, and has been the great advocate of this extension of the theory of parallelism. He extends it, in fact, to the whole surface of the earth, using the term *parallelism* in a certain modified sense, to render it applicable to lines drawn on a spherical instead of a plain surface. His theory asserts, that all great lines of dislocation, and, therefore, all mountain chains originating in them, wherever situated, may be grouped into *parallel systems;* and that all the lines or mountain chains belonging to any one system were produced simultaneously by one great convulsion of the earth's crust. This theory has been advocated by him many years; but he has recently published his latest views respecting it, and has made an important addition, which may, in fact, be regarded as an independent theory. Each of the parallel systems already mentioned will have its *characteristic direction,* to which all

* Treatise, p. 160.

the lines of that system are parallel. This new theory asserts that these characteristic directions are not determined, as it were, by accident or chance, but that they have certain relations to each other, so that the respective systems to which they belong are disposed over the earth's surface according to a distinct symmetrical arrangement.

"For the details of this curious theory I can only refer to the author's work, or to the Analysis which I gave of it last February, in my Address to the Geological Society. I feel it right, however, to add that, after an attentive examination of the subject, the evidence adduced by M. de Beaumont in support of the last-mentioned theory has failed to convey conviction to my own mind.

"With reference to the parallelism of contemporaneous lines of elevation, no one, I conceive, will deny the truth of M. de Beaumont's theory in its application to many geological districts of limited extent; but it will probably be the opinion of most English geologists that, in attempting to extend it to districts far remote from each other, he has overstepped the bounds of legitimate induction from facts with which we are at present acquainted. Every one, however, who studies M. de Beaumont's work, in whatever degree he may be disposed to adopt or reject the theoretical views of that distinguished geologist, will admit the ability and the knowledge which he has brought to bear on the subject, and the advantages which must result from the ample discussion which he has given it."*

Taking, therefore, all the data which has here been collated into account, we are constrained to come to the conclusion, that that which is intimately associated with, and indicates a disturbing cause of the once horizontal surface of strata (admitted to be contemporaneous in their formation), which is alike common "to small elevations and to mountain chains," but which "could not be produced by successive elevations of different points by the partial action of an elevatory force;" and yet is declared by others to have been in violent operation over immense tracts of territory, and, indeed, shown to have been thus prevalent at certain parts everywhere over the whole known surface of the earth—must have been contemporaneous. There could, in reality, have been only ONE GRAND AND SYNCHRONOUS elevation of HILLS, MOUNTAINS, MOUNTAIN CHAINS, and CONTINENTAL RIDGES throughout the world.

This opinion is strengthened by the consideration that, besides the more *local* indications of disturbance which the upheaving force has occasioned, it has afforded enduring symptoms of having acted according to a *more general principle and upon a more comprehensive scale* than what the writers of these conceptions seem to have imagined. I allude to the continental ridges and to the greater elevation of the continents and mountain chains within the tropics, and the nearer these approach to the equator, where the force was evidently at its maximum.

This prominent peculiarity; this evidence of the force having had a *maximum* and *minimum*, corresponding to parallels of latitude, and

* Athenæum for Sept., 1853, p. 1068.

profound curvatures by meridians of longitude, whose depth seems to be inversely as the degrees of the former, cannot be accounted for—has never, as far as I know, been attempted to be accounted for by any other theory, except by this, which attributes these effects to a world put into rotatory motion, with an angular velocity of fifteen degrees per hour, after its crust had been so constructed by deposition, and so consolidated by duration, as to admit of being broken up by the centrifugal force brought to bear upon it; and capable of being transformed into hill and dale, mountains and valleys, continental ridges and oceanic hollows, with all the variety of mineral structure, and central amorphous masses, which are now found to constitute the nucleii of elevated ranges, with stratified envelopes reclining, like stony drapery, upon their huge flanks and shoulders.

Recurring to the position established in a previous chapter, that the undermost masses of the non-rotating sphere, from being the most dense, became the central and most elevated parts of the various formations in the earth's present geological economy; I shall next proceed to enquire into the immediate results, or natural consequences, of this remarkable transformation, occasioned by the centrifugal impetus of the first rotation.

The most obvious idea which presents itself to the mind, is, that *motion* equal to the change of relative position *must* have taken place during the process. One of the first and most important effects of motion, or movement, amongst masses in contact with one another, is FRICTION—a property arising from the imperfect smoothness of surfaces, which impedes the motion of bodies whose surfaces are in contact.* Requiring to know something of the nature and effects of this property—now introduced to our notice for the first time—I shall retard the general argument until we are made somewhat acquainted with it. "*In friction,*" the *eighty-third* Theorem informs us, "*the amount of the resistance increases according to the roughness of the surfaces, and the force with which these, moving upon one another, are pressed together. Surfaces being equal, a double pressure will produce a double friction. That these results are but slightly affected by the velocity with which the surfaces move upon each other. And, therefore, any body moving under the effects of a given force will, in proportion to the increase of the asperity and pressure, be the more speedily deprived of its velocity, and reduced to a state of rest. And that* FRICTION *is a great source of heat independently of fire or flame.*"

From this it will appear obvious, that when an uneaven surface is made to slide upon another, under the influence of great force applied to the movement of heavy masses, one of the most immediate tendencies is to overcome, wear away, or grind down whatever asperities, may impede the progress of the moving body. In the event of either or both of the masses which present such asperities being composed of materials prone to split and break into detached

* Mechanics, in Cab. Cyc. p. 262.

pieces, they would most probably, by doing so, yield to the greater force; and the fragments, by moving along with the mass of greatest velocity, would, as far as they are capable, facilitate the general movement. The intensity of these results would be much increased, were the mass of greatest velocity forcibly ejected, or thrust through amongst others which had been formerly incumbent upon it; while comminution, and disintegration of the substances brought into contact, and the evolution of fierce heats would be the general consequence of the whole operation; and, finally, if this were done under water, and amongst calcareous and arenaceous materials, there would be produced a tenaceous cement capable of binding the whole together into one firm and inseparable mass.

Now, this is precisely what has taken place in the great cementing processes of the world, which Nature's Architect designed and wholly executed. By referring to the *hundred and second* Theorem, it will be perceived, "*That* CARBONIC ACID *abounds in nature, and appears to be produced under a variety of circumstances. It composes* 44-100*ths of the weight of limestone, marble, calcareous spar, and other natural varieties of calcareous earth. That on the application of a pretty strong heat to the various kinds of limestone (carbonate of lime), the carbonic acid is evaporated and the lime remains. And, that the basis of all effectual cements used in constructing works designed to be either occasionally or permanently under water, must be made from the hydrate of lime.*"

With this information on the mind, let us turn to the *twenty-second* Theorem, in which it is stated, "*That thick and extensive beds of breccia and conglomerate, in which the fragments are generally united by calcareous and other mineral substances, are found to intervene amongst the various series of the older and the secondary stratified masses, especially in the vicinity of mountain chains, and above and below the coal formations.*"

This clear but concise view of the case ought to make us fully aware of the wisdom and harmony of the plan, which provided such abundance of materials for the formation of those great cementing processes which, by the wonder-working hand of the Creator, combined the apparently heterogeneous materials of the earth's outer crust into one great, consistent, and firmly united whole.

As there may be many who are not sufficiently acquainted with the nature of these well known conglomerate and breccia bindings of the earth, so as to be capable of appreciating the perfection and adaptation of their construction; in which the masonic art seems to have been anticipated, and all that was necessary accomplished in one great and simultaneous day's work, over the whole surface of the earth; it is with great satisfaction I subjoin the following extracts, to excite in others the same pleasure and admiration I have myself enjoyed in their contemplation.

Professor Phillips says—

"Along the flanks of the Grampians, Lammermuir, and Cambrian mountains, the *old red sandstone formation* is chiefly a rude conglomerate of pebbles, torn by violent floods from the neighbouring high ground.

"We find, in fact, round all the mountain ranges, which for other reasons were presumed to have been uplifted before the carboniferous epoch began, some of the most remarkable conglomerate rocks which occur in the British strata. The character of these conglomerates, too, varies in direct relation to the proximity of the mountains. . . . . .

"The great qualities of those sediments imply, probably, some great physical changes of land and water, in situations not far removed. . . . ."

And again—

"When we behold conglomerate rocks, which hold fragments of other earlier deposits, and in these fragments the organic remains of still earlier periods, which had already undergone their peculiar mineral changes; when we collect the history of such an organic form—its existence in the sea—its sepulchre in a vast oceanic deposit of limestone—the induration of this rock—its uplifting by subterranean forces—the rolling of it into pebbles—the reunion of them into a totally different substance—it is evident that no greater folly can be committed, than to think to serve the cause of truth by contracting the long periods of geology into the compass of a few thousand years."*

M. de la Beche says—

"If we look to the Alps, we find, on all sides of that chain, beds of various depths of sandstone and conglomerates, forming a whole of very considerable thickness. If we also attentively examine the component parts of the sandstones and conglomerates, we find that the former are, generally, mere comminuted portions of the latter, and that both have been derived from the Alps. The whole is evidently a detritus of the Alpine rocks, and in it organic remains are by no means common, though they occur in certain situations. Such general appearances would seem to indicate a common origin, and that origin to be the Alps themselves. Rolled and comminuted detritus of the kind may either be derived by the continued action of what are termed actual causes, or some more violent exertion of forces, which, producing rapid motions in water and greater destruction of the land, should accomplish a far greater quantity of work in a given time. . . . . .

"It has been observed by M. Elie de Beaumont, that the calcareous portions of these regions of the Alps are separated from the older and non-fossiliferous rocks by a sandstone more or less coarse, which passes into conglomerate."

And again, a little further on, he adds—

"I cannot avoid connecting this conglomerate (that on the shores of the Magra), and that on the Lake of Como, with the conglomerates and sandstones of the Valloisine and other parts of the western Alps, and referring them to the same epoch of formation—one in which water, with certain velocity, ground down portions of pre-existing rocks, and which was attended with a state of things when a great abundance of carbonate of lime was deposited.

* Treatise, pp. 104, 115, 116, 293.

"Taken as a mass, this group may be considered as a deposit of conglomerate, sandstone, and marl, in which limestones occasionally appear in certain terms of the series; sometimes one calcareous deposit being absent, as the muschelkalk is in England; sometimes the Zechstein, as in the east and south of France; and sometimes both being wanting, as in Devonshire. The conglomerates, or todtliegendes, commonly occupy the lowest position, though conglomerates are occasionally noticed higher in the series; the sandstones form the central part, and the marls occur in the higher place." . . . . .

And in conclusion, from M. de la Beche—

"Another circumstance also lends probability to this view (namely, that the eruption of the trappean rocks caused the conglomerate), and that is, the occurrence of pebbles cemented in certain inferior beds by a kind of semi-trappean paste, containing crystals of a kind of felspar. Such a cement might possibly have resulted from the upburst of igneous rocks, accompanied by various gases beneath a mass of water; when some of the matter may have combined so as to form a cement. Without some such hypothesis the cement seems of very difficult explanation."*

Mr. Lyell, when treating of the old red sandstone, states—

"The beds next below the yellow sandstone are well seen in a large zone of old red, which skirts the southern flank of the Grampians, ... where the entire mass of strata are several thousand feet thick, and may be divided into the following principal masses—1st. Red and mottled marls; 2nd. Conglomerates of vast thickness.

"The eastern chain of the Andes consists chiefly of sandstones and conglomerates of vast thickness, the materials of which are derived from the veins of the western chain. The pebbles of the conglomerates are, for the most part, rounded fragments of the fossiliferous slates before mentioned."

And when describing the effects of granitic injections, he says—

"Professor Sedgwick and Mr. Murchison conceive that this granite (near Brora, in Sutherlandshire) has been upheaved in a solid form; and that in breaking through the submarine deposits, with which it was, perhaps, originally in contact, it has fractured them so as to form a breccia along the line of junction.

"It is chiefly in the case of calcareous rocks, that solidification takes place at the time of deposition. But there are many deposits in which a cementing process comes into operation long afterwards. We may sometimes observe, where the water of ferruginous or calcareous springs has flowed through a bed of sand or gravel, that iron or carbonate of lime has been deposited in the interstices between the grains or pebbles, so that in certain places the whole has been bound into stone, the same set of strata remaining, in other parts, loose and incoherent. Proofs of a similar cementing process are seen in a rock at Kelloway, in Wiltshire. . . . . .

"In some conglomerates, like the pudding-stone of Hertfordshire, pebbles of flint and grains of sand are united by a siliceous cement so firmly, that if a block be fractured, the rent passes as readily through the pebbles as through the cement."†

* Manual of Geology, pp. 210, 323, 329, 400, 404.

† Elements, vol. i. pp. 7, 38, 101, 365. Vol. ii. pp. 148, 357, 370. Vol. i. pp. 74—76.

Mr. Miller observes, in describing the conglomerate of the old red sandstone—

"The first scene in the *Tempest* opens amid the confusion and turmoil of the hurricane, amid thunders and lightnings, the roar of the wind, the shouts of the seamen, the rattling of the cordage, and the wild dash of the billows. The history of the period represented by the old red sandstone seems, in what now forms the northern half of Scotland, to have opened in a similar manner. The finely laminated lower tilestones of England were deposited evidently in a calm sea.

"During the contemporary period in our own country, the vast space which now includes Orkney and Lochness, Dingwall and Gamrie, and many a thousand square miles besides, was the scene of a shallow ocean, perplexed by powerful currents, and agitated by waves. A vast stratum of water-rolled pebbles, varying in depth from 100 feet to 100 yards, remains in a thousand different localities, to testify the disturbing agencies of this time of commotion. The hardest masses which the stratum encloses, porphyries of vitreous fracture, that cut glass as readily as flint, and masses of quartz that strike fire quite as profusely from steel, are yet polished and ground down into bullet-like forms, not an angular fragment appearing in some parts of the mass for yards together. The debris of our harder rocks rolled for centuries in the beds of our more impetuous rivers, or tossed for ages along our more exposed and precipitous sea-shores, could not present less equivocally the marks of violent and prolonged attrition than the pebbles of this bed. And yet it is surely difficult to conceive how the bottom of any sea should have been so violently and so equally agitated for so greatly extended a space as that which intervenes between Mealforvonie, in Invernessshire, and Pomona, in Orkney, in one direction, and between Applecross and Trouphead in another, and for a period so prolonged that the entire area should have come to be covered with a stratum of rolled pebbles of almost every variety of ancient rock, fifteen storys' height in thickness. The very variety of its contents shows that the period must have been prolonged. A sudden flood sweeps away with it the accumulated debris of a range of mountains; but to blend together, in equal mixture, the debris of many such ranges, as well as to grind down their roughnesses and angularities, and fill up the interstices with the sand and gravel produced in the process, must be a work of time. I have examined with much interest, in various localities, the fragments of ancient rock enclosed in this formation. Many of them are no longer to be found *in situ*, and the group is essentially different from that presented by the more modern gravels. The period of this shallow and stormy ocean passed, the bottom, composed of the identical conglomerate which now forms the summits of some of our loftiest mountains, sank throughout its wide area to a depth so profound as to be little affected by tides or tempests. During this second period there took place a vast deposit of coarse sandstone strata, with here and there a few thin beds of rolled pebbles. The general subsidence of the bottom still continued, and after a deposit of full ninety feet had overlain the conglomerate, the depth became still more profound than at first. A fine semi-calcareous, semi-aluminous deposition took place in waters perfectly undisturbed; and here we first find proof that this ancient ocean literally swarmed with life—that its bottom was covered with minia-

ture forests of algæ, and its waters were darkened by immense shoals of fish."*

These evidences are so concurrent in themselves, and so conclusive on the whole, in favour of the position sought at present to be established, respecting these singular formations, which intervene amongst the others, in almost all tracts of country which have been the theatre of great disturbances, that no further testimony is needed to prove their existence, in precisely the geological localities where the Dynamical Theory required for its perfection, that they should be found; but occasion will be taken, nevertheless, to say a few words as to the explanations which have, hitherto, been given respecting their origin.

It is, I believe, generally known, that breccias and conglomerates have ever been interesting objects of enquiry to geologists, having often been made use of as guides to direct their researches, and to point out the relative antiquities of the masses between which they happen to occur. Unfortunately, however, like many other natural evidences, their true meaning has, sometimes, been misinterpreted! But in what other branch of Science have not mistakes also been made? If the detached fragments, formed by subsequent concretion into breccias, have been construed into undeniable proofs, that the rocky masses from whence they were separated, formed preexisting mountains and continents which had through ages undergone disintegration by catastrophes supposed to be peculiar to the formation of worlds in their nascent state; surely we ought not too severely to condemn those misinterpretations, occasioned by appearances so specious and apparently so infallible: for it must be remembered that these natural finger-posts, particularly when taken in the abstract, often point in *opposite directions;* and, considering that no one ever before suspected that they owed their origin to *the same dynamical causes which simultaneously elevated the continents and mountains of the world,* it is by no means surprising, that *the reading* of some should have made converts of others, and among these, of some of the most accomplished geologists of the past and present eras.

But, viewed as they are in this Theory, the first impression which presents itself to the mind is the infinite wisdom which willed them into existence; forming, as they do, the great cementing processes by which the rocky crust of the globe is so admirably bound together, and the heterogeneous materials of its outer crust united into

* Old Red Sandstone, pp. 272—275. It is scarcely possible for even an implicit believer in the Dynamical Theory, more perfectly to describe what would take place after the earth was made to rotate for the first time, and when the ancient waters, at the commencement, rushed towards the equator surcharged with debris, sand, and silt, to complete the figure of equilibrium, and having accomplished this, assumed a death-like stillness, and deposited the fine particles; while the subsequent evaporation, when the atmosphere was formed, caused the dessication of the very finest, which had, until then, remained.—AUTHOR.

one impervious whole; rough, it is true, to our microscopic eyes, but no doubt preserving the most perfect proportion to its own gigantic dimensions! When we consider that the whole of this wonderful operation, extending, though not continuously, over nearly the whole surface of the globe, was begun and completed within the short space of two natural days, we cannot fail to be impressed with increasing admiration and reverence; while we acquire juster conceptions of the power and the attributes of that Being, "who weighed the hills in his balance, and meted out the ocean in the palm of his hand."

These formations, thus wisely and powerfully brought into existence, appear to have had other very important ends to serve. They greatly facilitated the relative movements between the primary amorphous masses and the stratified rocks, and also between the different formations of strata; enabling them to pass each other, in order to assume their places in the elevations they were destined to form, with less evolution of heat than would otherwise have taken place, had the moving masses been composed of fibrous and less brittle materials, resisting disintegration, and supplying no natural rollers to "lighten the heavy load along." For, although the *heat* evolved by those moving masses was absolutely essential for the accomplishment of important mineralogical phenomena, such as the formation of veins, &c., yet numberless means were adopted for confining its effects to the localities where it was most required, and for modifying its application. One of these appears to have been *the creation of the great breccia and conglomerate beds* which have just been contemplated; another, the interposition of alternate layers of aluminous material (an indifferent conductor of heat) between the primary masses and the calcareous formations; and both aluminous and calcareous strata between the injected rocks and the coal measures, in order to defend the latter from too intense a degree of fusion, during the convulsive movements of a world starting into life; which, otherwise, would have deprived the carboniferous series of those essential qualities which now render them so useful.

Meanwhile, it should be remembered, that as the coal measures, when these revolutions were taking place, formed the uppermost strata of the ancient world, they would naturally be in so soft and flexible a state as would permit of their yielding, in a certain degree, to whatever form was impressed upon them, by the more rigid masses with which they were brought violently into contact; their plasticity, at the same time, enabling and inducing them to assume the inflexions of the older strata on which they now repose. The evidence for the truth of these assertions is still discoverable by the forms in which the carboniferous concretions, and their associated shales are found in the various workings of the coal mines; while the testimony derived from the perfection and uninjured condition of

their fossil vegetable remains, sufficiently evince, that they were not removed far from where they had been formed.

The fact of the coal measures presenting these peculiar features, in a very striking degree, is so abundantly evidenced by what is said of them in every geological treatise, that it will be quite superfluous to arrest the progress of the general argument by going into details. They have been frequently alluded to in quotations already given, and they will, of themselves, come out more prominently as we proceed.

It will likewise, hereafter, be made manifest, that with similar provident wisdom to that by which the coal measures were thus shielded *underneath* from the fusing heat of the moving mountain masses, the elevation of these very mountains was made the means of spreading abroad an immense mass of *debris*, which being conveyed by the rushing tumultuous ocean, and deposited upon the upper surface of these carboniferous formations, protected them, alike, from the denuding and transporting influence of that very ocean, in its course towards the equatorial regions; from the sudden evaporation that took place when the land was separated from the water; and from the slower, but no less destructive, agency of the atmosphere which was shortly thereafter to be formed. Indeed, the closer the works of creation are examined into, the more thoroughly shall we be convinced of the beneficent forethought of the Creator.

By the concluding paragraph of the *eighty-third* Theorem, it will be seen, that another immediate effect of *friction* is, "*heat, independently of fire or flame;*" *and, consequently, that the degree of heat is in proportion to the friction.*

As friction—according to the evidences connected with the same Theorem—depends on the amount of the pressure, together with the roughness of the surfaces brought into contact, it follows, *that the amount which would necessarily be evolved by the movement of the continents and mountain chains, must have been almost infinite*, judging by our ideas of friction proceeding from mechanical causes: while the heat must have arisen to a corresponding degree of intensity—a fact which will appear more evident when account is taken of the combustible nature of the mineral materials of which these mountain masses are composed.*

It is, likewise, to be considered that, as the degree of friction, and, consequently, of heat, depend on the amount of *motion*, the rocky masses would be subjected to both of these results in direct proportion as they became the central and more elevated portions of mountain chains, inasmuch as these had to traverse greater distances before they reached their destined height. A composition of these gives, as a common result, *that the symptoms of fusion should most*

* See Theorems 98, 99, 103.

strongly pervade the neighbourhood of the greatest and most elevated masses, which have been forcibly intruded among the associated strata.

This is precisely what the researches of geologists reveal to us has taken place; for by the *twentieth* Theorem it will be perceived, "*That considering the granitic, trappean, serpentinous, and other rocks of similar origin, to have been injected amongst the stratified masses; and that evidence still remains of great heat having been present when and where these protrusions took place—shown as well by the structure of the igneous injections themselves as by the fused, altered, rent condition, and slaty cleavage of the rocks contiguous to them—it is, likewise, considered that the extent of the alteration, and the insensible transition of the altered mass, are in direct proportion to the volume of that which has been injected.*"

The following are some of the evidences declarative, in the most striking manner, of the effects produced by *fusion* among the mineral masses; and which can be traced to their source, by a chain of causes and effects which link the fusion of the injected rocks to the heat, occasioned by the friction which necessarily arose from the protorotation of the earth on the first day of the Mosaic week.

"The peculiar condition of the rocks," says Professor Buckland, "which form the side walls of granitic veins and basaltic dykes, affords another argument in favour of their igneous origin; thus, wherever the early slate rocks are intersected by granitic veins, they are usually altered to a state approximating to that of fine-grained mica slate, or hornblende slate. The secondary and tertiary rocks, also, when they are intersected by basaltic dykes, have frequently undergone some change; beds of shale and sandstone are indurated and reduced to jaspar; compact limestone and chalk are converted to crystaline marble; and chalk flints altered to a state like that resulting from heat in an artificial furnace."*

M. de la Beche thus expresses himself with respect to the *unstratified rocks*:—

"The rocks constituting this natural group are widely distributed over the surface of the world, are found mixed with almost all the stratified rocks, and bear every mark of having been ejected from beneath. They commonly occur, either as protruded masses, as overlapping masses resulting from the spread of matter after ejection, or as veinstones filling fissures, apparently consequent on some violence to which the strata have been subjected. . . . . . .

"Such are the rocks," he continues, after having given a minute description of each, "commonly considered unstratified. It will have been seen, that they so pass into one another that distinctions are not easily established between them. Mineralogical granite passes through various stages, and graduates into the compounds named greenstone, and others of the trappean class.

"Thus far we have only seen granite rising through and covering other rocks in considerable masses, but we have also evidence in granite veins, that the matter of the rock was in such a state of igneous fusion, as to pene-

* Bridgewater Treatise, vol. ii. p. 9.

trate into thin clefts opened in stratified and older rocks by some violence, such as probably resulted from the upburst of the igneous matter accompanied by elastic vapours, ... the intruding substance breaking off and including in it all loose fragments, and those projecting portions which opposed the fury of the injection.

"According to Mr. Aikin, a good example of the apparent inter-stratification of greenstone with the coal measures is observable at *Birch Hill Colliery*, Staffordshire. The bed seems to be connected with a mass of trap on one side, whence it has been injected amongst the strata, altering the coal where it covers it by depriving it of its bitumen.

"There is a trap dyke, described by Mr. Hill, as occurring at *Walker Colliery*, Newcastle, which has converted the coal contiguous to it into coke.

"The annexed figure will illustrate a considerable fracture and alteration in the limestones at the *Black Head, Babbacombe Bay*, Devon, effected by the eruption of greenstone. . . . . . The slates and limestones have evidently suffered, not only from the mechanical action of the erupted greenstone, but also chemically from the proximity of the mass in a state of igneous fusion.

"Mr. Lyell has described a serpentine dyke which cuts through a sandstone near West Balloch Farm, in Forfarshire. . . . . . The serpentine is also said to be bounded on the left bank of the *Carity* 'by a vertical mass of sandstone conglomerate evidently much altered, some parts approaching to jaspar in hardness and appearance,' in which some of the quartz pebbles have even been fractured and reunited. This fracture of the quartz pebbles is precisely what we should expect from a sudden application of heat, and would speak strongly in favour of the once igneous fusion of the serpentine in the dyke, if any evidence were wanting.

"When we recollect that the intrusion of igneous rocks has been sufficient to convert chalk into granular limestone, in the North of Ireland, we need not be surprised that other rocks have been altered by the intrusion of similar substances. The slates, for instance, in many parts of the country surrounding the granite of Dartmoor, Devon, have suffered from its intrusion. . . . . . These changes are no more than we should expect from the intrusion of a mass in a state of igneous fusion. . . . . . Indeed, cases of induration and alteration of rocks in contact with igneous products are so common, that it would be useless further to enumerate them."*

"We have now," says Mr. Lyell, "to examine those crystaline (or hypogene) strata to which the name of *metamorphic* has been assigned. This last term expresses a theoretical opinion that such strata, after having been deposited from water, acquired, by the influences of heat and other causes, a highly crystaline texture. . . . . . Having said thus much of the mineral composition of the metamorphic rocks, I may combine what remains to be said of their structure and history with an account of the opinions entertained of their probable origin."

In consequence, somewhat farther on, he continues—

"It has been seen, that geologists have been very generally led to infer, from the phenomena of joints and slaty cleavage, that mountain masses, of which the sedimentary origin is unquestionable, have been acted upon simultaneously by vast crystaline forces. That the structure of fossiliferous

* Manual, pp. 486—510.

strata has often been modified by some general cause since their original deposition, and even subsequently to their consolidation and dislocation, is undeniable. These facts prepare us to believe that still greater changes may have been worked out by a greater intensity, or more prolonged development of the same agency, combined, perhaps, with other causes. Now we have seen that near the contact of granitic veins and volcanic dykes, very extraordinary alterations in rocks have taken place, more especially in the neighbourhood of granite. . . . . . The stratified rocks (Fiord of Christiana, Norway), replete with shells and zoophytes, consist chiefly of shale, limestone, and some sandstone, and all these are invariably altered near the granite for a distance of from 50 to 400 yards. The aluminous shales are hardened and have become flinty. Ribboned jaspar is produced by the hardening of alternate layers of green and chocolate coloured schists. . . . . In some places the siliceous matter of the schist becomes a granular quartz, and when hornblend and mica are added, the altered rock loses its stratification and passes into a kind of granite. The limestone, which at points remote from the granite is of an earthy texture, blue colour, and often abounds in corals, becomes a white granular marble near the granite, sometimes siliceous, the granular structure extending occasionally upwards of 400 yards from the junction; and the corals being for the most part obliterated, though sometimes preserved even in the white marble. . . . . .

"Although the precise nature of these altering causes is obscure, we must suppose the influence of heat to be in some way connected with the transmutation, if, for reasons before explained, we concede the igneous origin of granite. . . . . .

In conclusion from this intelligent and instructive geologist:—

"I shall mention," says he, "one or two examples of alteration on a grand scale, in order to explain the kind of reasoning by which we are led to infer that dense masses of fossiliferous strata have been converted into crystaline rock.

"*Northern Apennines.—Carrara.*—The celebrated marble of Carrara, used in Sculpture, was once regarded as a type of primitive limestone. It abounds in the mountains of Massa Carrara, or the 'Apuan Alps,' as they have been called, the highest peaks of which are nearly 6,000 feet high. Its great antiquity was inferred from its mineral texture, from the absence of fossils, and its passage downwards into talk-schist, and garnetiferous mica-schist. Now, the researches of MM. Savi, Boué, Pareto, Guidoni, De la Beche, and especially Hoffmann, have demonstrated that this marble, once supposed to be formed before the existence of organic beings, is, in fact, an altered limestone of the oolitic period, and the underlying crystaline schists are secondary sandstones and shales, modified by plutonic action.

"*Alps of Switzerland.*—In the Alps, analogous conclusions have been drawn respecting the alteration of strata on a still more extended scale. In the Central or Swiss Alps, the primary fossiliferous and older secondary formations disappear, and the cretaceous, oolitic, and liassic strata graduate insensibly into metamorphic rocks, consisting of granular limestone, talc-schist, talcose-gneiss, micaceous-schist, and other varieties."*

"The centre or axis," says Professor Phillips, "of mountain groups, and consequently of the disturbing movement (during its upheaval), is generally

* Lyell's Elements of Geology, vol. ii. pp. 379, 386, 401, 403—407, 419, 421.

seen to be a mass of *unstratified rock*, such as granite, sienite, &c., which shows, by a variety of circumstances, that it was not deposited in water, but rather crystalized from igneous fusion. Very often, indeed generally, proofs of its having been in a state of fusion at the time of the elevation of the strata, are found in the extension of veins of the crystalized into the sedimentary rocks, accompanied by the characteristic effects of heat.

"We are thus led to associate the phenomena of the disturbance of strata with the eruption of the crystalized rock from beneath; and though the latter is indeed not exactly the cause of the former, but rather a concomitant effect of some general dynamical agency, geologists are not greatly to be censured who describe the phenomena as they appear, and speak of the disturbed positions of the strata, as *effects* of the elevation of unstratified rocks.

"What, then, is the fruit of all this discussion? It is the conviction that the gneiss, mica-slate, primary limestone, quartz rock, &c., are stratified rocks; the most important evidence being the alternation of these different rocks, and the lamination of different substances in them, but that the causes which tend among all rocks to complicate the stratification with new structures, have gone to the maximum in these the oldest of all; the principal of these causes being heat, either locally exhibited in the neighbourhood of igneous crystalized rocks, or generally pervading the whole mass of deposits."*

These quotations must be sufficient to convince any one, that when geologists have occasion to reason respecting the symptoms of fusion among the older rocks, they never doubt that it existed in the *intruded masses;* these are, at once, assumed as having been injected, while yet liquid, by igneous fusion; and the whole of their reasoning is directed to exhibit the effects on the masses which are found in their immediate vicinity, while the fact of the injected mass itself having been fused is never even called in question. This, of course, is an important concession in favour of the views here adopted; and it remains only for me to be able to prove *the source of the heat, whose existence is thus so unanimously and unhesitatingly admitted.*

These symptoms of heat are, generally, found to exist in a ratio proportioned to the *friction* supposed to have been experienced; that is, in proportion to the mass of matter moved out of perfect horizontality, the distance it had to go, and the asperities overcome in moving from horizontality into the present posture.†

* Treatise, pp. 61, 75.

† It is particularly to be observed, that while the heat here treated of had no connection whatever with the *warmth* existing in the primitive world, neither did it, in any manner, proceed *directly* from the action of the first rays of light; for, had it done so, it would not only have acted *equally over all the surface* of the earth, but *would have affected the surface more than the internal rocky masses,* a tendency precisely the reverse of what appears to have been designed during the great revolution now under consideration. For, had it been so produced, before it could have effected the fusion of rocks forming the interior of mountains and elevations, in order to produce their veins, ramifications, and other attendant circumstances, it must have first passed *through,* and consequently, to a certain extent, *destroyed the whole* of the *calcareous* and *carboniferous* formations which surround and overlie the primary, a result expressly sought to be avoided, and arranged for accordingly.—AUTHOR.

The views adopted by this theory lead to the conclusion, "*That as the heat which fused the primary rocks proceeded entirely from friction, engendered by motion acting on their combustible materials, it must have reached its maximum in the interior of elevations, where the motion was likewise greatest.*

In confirmation of this doctrine, which is peculiar to the Dynamical Theory, I have merely to take up and substantiate the concluding paragraph of the *twentieth* Theorem, namely: "*That the extent of the alteration and the insensible transition of the altered mass, are in direct proportion to the volume of that which has been injected.*" Applying this to the primary strata, and transition series, it will satisfactorily account for the prevalence of the crystaline texture in both of these formations; for, if the heat which proceeded from a trap, or a greenstone dyke has been, in numberless instances, sufficient to alter the texture, to a certain extent, of the strata in their immediate vicinity, to what extent must these fierce heats have penetrated, which radiated from the fused granitic nucleii of entire mountain ranges? In considering this, it should be remembered, that the intensity of "the radiation of heat is in direct proportion to the magnitude of the radiating surface."*

It is presumed, that what has been adduced will serve to explain what has hitherto been an embarrassing point in geology, namely: the prevalence of crystaline stratiform rocks among the primary and transition series. For instance—Marble is known to be carbonate of lime, fused under great heat, and a corresponding pressure. Beds of shale and sandstone have, by induration from heat, been reduced to jaspar; and these, together with other rocks under similar circumstances, have all along demanded the supposition of the presence and action of greater heats than could be admitted to have been general, when the character and texture of other strata, somewhat removed from these foci of fusion, were taken into consideration. By viewing the subject in this light, the difficulty vanishes at once; and the *altered* and *crystaline* textures of the older strata are recognised to be quite in accordance with the other prominent feature in their character, viz., deposition from aqueous solution—for by this it has been shown, that the same cause which raised them from the horizontal position in which they were formed, has likewise fused, crystalized, and reconsolidated them.

Having so recently had occasion to adduce evidences confirmatory of the *fused* and *altered* condition of the formations which are found contiguous to intruded amorphous masses—a branch of this same argument—on this occasion the proofs will be restricted to such as show the prevailing *geological sites* of these *altered rocks*, and the accordance of their character and features in general, with previous assumptions.

Scarcely any passage can be more conclusive than the one already

* Evidences in connection with the 57th Theorem.

given repeatedly from Professor Phillips's work, wherein he shows the immediate connection between the disturbed state of the strata and the eruption of unstratified rocks. When treating of slaty cleavage planes and *symmetrical joints*, and contrasting them with *stratified structure*, he goes on to say—

"They are, in fact, superposed structures, and from what is known of the introduction of similar structures into ordinary clays and shales, by the side and in the vicinity of igneous rocks, independent of general considerations, such as the high degree of induration of these rocks, there is little doubt that the agency of heat is the general cause of these phenomena of structure."*

Professor Playfair, in one of his pithy illustrative sentences, when reasoning about "whin-stone," observes—

"If all these circumstances are put together, there appears but one conclusion which can be drawn from them. If the mass in which these rocks are now embedded be supposed to have been once in fusion, and forcibly thrown up from below, invading the strata, and carrying the fragments along with it, the whole phenomena admit of an easy explanation, and all the circumstances accord with one another. Indeed, the effects of motion and heat can scarcely be more clearly expressed than they are here, or the subject in which these powers resided more distinctly pointed out."†

Mr. Miller bears testimony to the same effect, by the description he gives of the elevation of mountains.

"In most of our hills," he observes, "the upheaving agency has been actively at work, and the space within is occupied by an immense nucleus of inferior rock, around which the upper formation is wrapped like a caul, just as the vegetable mould or diluvium wraps up this superior covering in turn.

"One of our best known Scottish mountains—the gigantic Ben Nevis—furnishes an admirable illustration of this latter construction of hill. It is composed of three zones or rings of rock, the one rising over and out of the other, like the cases of an opera glass drawn out. The lower zone is composed of gneiss and mica-slate—the middle zone of granite—the terminating zone of porphyry. The elevating power appears to have acted in the centre, as in the well known case of Jorullo, in the neighbourhood of the City of Mexico, where a level tract, four square miles in extent, rose about the middle of the last century, into a high dome of more than double the height of Arthur's Seat. In the formation of our Scottish mountain, the gneiss and mica-slate of the district seem to have been upheaved, during the first period of plutonic action in the locality, into a rounded hill of moderate altitude, but of huge base. The upheaving power continued to operate—the gneiss and mica slate gave way at top—and out of this lower dome there arose a higher dome of granite, which in an after and terminating period of the internal activity, gave way in turn to yet a third and last dome of porphyry. Now, had the elevating forces ceased to operate just ere the gneiss and mica-slate had given way, we would have known nothing of the interior nucleus of granite—had they ceased just ere the granite had given way we would have known nothing of the yet deeper nucleus of porphyry;

* Pages 82, 83. † Playfair's Huttonian Theory, vol. i. p. 301.

and yet the granite and the porphyry would assuredly have been there. Nor could any application of the measuring rule to the side of the hill have ascertained the thickness of its outer covering—the gneiss and the mica-schist."*

Mr. Lyell says—

"Although strata in the neighbourhood of dykes are thus altered in a variety of cases, shale being turned into flinty slate or jaspar, limestone into crystaline marble, sandstone into quartz, coal into coke, and the fossil remains of all such strata wholly or in part obliterated, it is by no means uncommon to meet with the same rocks, even in the same districts, absolutely unchanged in the proximity of volcanic dykes."

Again—

"In proof of the mechanical force which the fluid trap has sometimes exerted on the rocks into which it has intruded itself, I may refer to the Whin-sill, where a mass of basalt, from 60 to 80 feet in height, is in part wedged in between the rocks of limestone and shale, with which they were united. . . . . .

"When trap dykes were described in the preceding chapter, they were shown to be more modern than all the strata which they traverse. . . . . .

"When plutonic rocks send veins into strata, and alter them near the point of contact, in the manner we have before described, it is clear that, like intrusive traps which have been separated from the great mass of limestone and shale, they are newer than the strata which they invade and alter.

"We have seen that, near the immediate contact of granitic veins and volcanic dykes, very extraordinary alteration in rocks have taken place, more especially in the neighbourhood of granite. We learn from the investigations of M. Dupenoy, that in the Eastern Pyrenees there are mountain masses of granite posterior in date to the formations called lias and chalk of that district, and that these latter fossiliferous rocks are greatly altered in texture, and often charged with iron ore, in the neighbourhood of the granite."

And finally, from this geologist—

"In considering, then,"—he says—"the various data already enumerated, the forms of stratification in metamorphic rocks, their passage on the one hand into the fossiliferous, and on the other into the plutonic formations, and the conversions which can be ascertained to have occurred in the vicinity of granite, we may conclude that gneiss and mica-schist may be nothing more than altered micaceous and argillaceous sandstones, that granular quartz may have been derived from siliceous sandstone, and compact quartz from the same materials. Clay-slate may be altered shale, and granular marble may have originated in the form of ordinary limestone, replete with shells and corals, which have since been obliterated; and, lastly, calcareous sands and marls may have been changed into impure crystaline limestone. 'Hornblend-schist,' says Dr. M'Culloch, 'may at first have been mere clay.' And, 'the anthracite found associated with hypogene rocks may have been coal, for we know that, in the vicinity of some trap dykes, coal is converted into anthracite.' "†

* Old Red Sandstone, pp. 58—60. It is considered by this theory that the upheaval took place simultaneously by the protorotation of the earth.—AUTHOR.

† Elements of Geology, vol. ii. pp. 224—226, 241, 350, 401—405, 412, 413.

SECTION V.

GEOLOGICAL PHENOMENA RESULTING FROM THE EARTH'S PROTOROTATION.

CHAPTER XXI.

Evidences of the existence in former times of fusion in the primary rocks, derived from their *internal* or *mineralogical* structure. Carbonate of lime fused under pressure—mineralogical results. Crystalization proceeding from igneous fusion. Geological evidences to prove that a considerable proportion of the rocky crust of the Earth is crystaline in its texture. Essential difference between rocks, properly called crystaline, of older formation, and those resulting from modern volcanoes, called lavas.

Having thus established the presence, in former times, of fusion amongst the primary stratified and unstratified rocks, and the stratifications of the secondary series, by tracing its consequences to those formations which are in contact with them, and which, for the sake of perspicuity, may be called *the external evidences of that intense heat;* I must next endeavour to bring home the same degree of evidence as to its existence from the structure of those rocks, by enquiring whether in their *mineralogical* character, and other *internal* circumstances, they afford corresponding marks of having been subjected to that fierce heat, and consequent fusion, which are recognisable, externally, at their junction with other rocks.

To do this properly, however, I must depart somewhat from the straight line of the argument, and direct the attention for a moment to some of the phenomena which usually accompany the liquifaction of mineral masses by heat. These are—*First.* The results which proceed from heating mineral masses under pressure, and permitting them to cool slowly, or by excluding them from the action of atmospheric air; and, *secondly,* Crystalization from igneous liquifaction. These subjects will occupy the attention in the order in which they stand.

The *hundred and first* Theorem states, " *That by experiment* it has been proved, that if carbonate of lime be heated under a pressure equal to* 1,700 *feet of sea water, or to a column of liquid lava* 600 *feet high, so as to prevent the escape of its carbonic acid, it may be melted at a*

* By Sir James Hall.

temperature even not higher than 22° of Wedgewood's scale. That by this process it acquires considerable hardness and closeness of texture, approaching, in these qualities, as well as in fracture and specific gravity, to the finer kind of limestone or marble. And latterly it has been discovered, that even without compression, carbonate of lime may be fused by the sudden application of violent heat, or by submitting it to heat in a large mass."

The following succinct details of the scientific experiments on which this Theorem is founded, may be interesting to the reader; and being, by their character, quite conclusive, will close the argument for this particular point:—

"The alterations of limestone in contact with trappean rocks is sufficiently common, producing a greater or less amount of crystalization, in accordance with the well-known experiments of Sir James Hall (*Transactions of the Royal Society of Edinburgh*, vol. vi.), who has proved, that when carbonate of lime is subjected to great heat beneath sufficient pressure, it does not part with its carbonic acid, but that it is fused and rendered crystaline—a fact previously doubted."*

Mr. Lyell says—

"These phenomena," manifested by the volcanic rocks of the post-pliocene period, "are in perfect harmony with the results of the experiments of Sir James Hall and Mr. Gregory Watt, which have shown that a glassy texture is the effect of sudden cooling, and that, on the contrary, a crystaline grain is produced where fused minerals are allowed to consolidate slowly and tranquilly under high pressure."

And again—

"The experiments of Gregory Watt, in fusing rocks in the laboratory, and allowing them to consolidate by slow cooling, prove distinctly that a rock need not be perfectly melted in order that a re-arrangement of its component particles should take place, and a partial crystalization ensue. We may, therefore, easily suppose, that all traces of shells and other organic remains may be destroyed; and that new chemical combinations may arise, without the mass being so fused, as that the lines of stratification should be wholly obliterated."†

This celebrated experiment has been interwoven by Sir John Herschel so admirably into the evidences brought forward by him in favour of the Copernican system, that I cannot resist giving the passage in his own language. When showing the remarkable confirmation which that system of the celestial mechanism received, by the subsequent discovery of the crescent form which Venus assumes in certain parts of her orbit around the sun, he goes on to say—

"The history of science affords, perhaps, only one instance analogous to this, namely, when Dr. Hutton expounded his theory of the consolidation of rocks by the application of heat, at a great depth below the bed of the ocean, and especially of that of marble by actual fusion; it was objected

* Manual of Geology, by H. T. de la Beche, p. 497.
† Elements, vol. ii. pp. 259, 406.

that, whatever might be the case with others, with calcareous or marble rocks, at least, it was impossible to grant such a cause of consolidation, since heat decomposes their substance and converts it into quick lime, by driving off the carbonic acid, and leaving a substance perfectly infusible. To this he replied, that the pressure under which the heat was applied would prevent the escape of the carbonic acid, and, that being retained, it might be expected to give that fusibility to the compound which the simple quicklime wanted. The next generation saw this anticipation converted into an observed fact, and verified by the direct experiments of Sir James Hall, who actually succeeded in melting marble, by retaining its carbonic acid under violent pressure."*

With regard to *crystalization by fusion*, which seems to have acted so important a part in the ultimate mineralogical composition of the primary and other secondary formations; the following two Theorems, which have relation to it, are brought forward, in succession. The attention is more especially directed to the last.

The *hundred and eleventh* Theorem states, "*That when substances are rendered fluid, with perfect mobility amongst their particles, either by igneous fusion or by solution, and are suffered to pass with adequate slowness into the solid state, the attractive forces—called homogeneous attraction—frequently re-arrange these particles into regular polyhedral figures or geometrical solids; to which the name of* CRYSTALS *has been given. That mere approximation of the particles is not, however, alone sufficient to produce crystalization, they must also change the direction of their poles from the fluid collocation to their position in the solid state, which may be effected by the following means, namely,* 1. *By vibratory motion communicated either from the atmosphere or any other moving body.* 2. *By contact of any part of the fluid with a point of a solid of similar composition previously formed, or other substance.* 3. *By the slow and continued agency of voltaic electricity operating in water. That darkness, in most instances, favours crystalization. That heat, likewise, exercises considerable influence on these phenomena; and, lastly, that the same substance, in crystalizing, not unfrequently assumes a diversity of forms; though, in general, the same substance, under similar circumstances, assumes the same form.*"

In continuation of the same subject, the *hundred and twelfth* Theorem says—"*That most of the rocks which compose the mineral crust of the earth are in a crystalized state. Granite, for example, consisting of crystals of quartz, felspar, and mica; marble of crystals of carbonate of lime, &c. And that the whole phenomena attendant on crystalization go to prove that substances having the same crystaline form must consist of ultimate atoms, having the same figure, and arranged in the same order, so that the form of crystals is dependent on their atomic constitution.*"

Some of the evidences which substantiate those parts of the above Theorems which relate to the present enquiry are subjoined.

* Discourse on Natural Philosophy, Cab. Cyc. pp. 269, 270.

"It cannot be supposed," says Sir John Herschel, "that these and other tangible qualities, as they may be called, should subsist in solids without a corresponding mechanism in their internal structure. That they have such a mechanism, and *that* a very curious and intricate one, the phenomena of crystalography sufficiently show.

"This interesting and beautiful department of natural science is of comparatively very modern date. That many natural substances affected certain forms must have been known from the earliest times. But till the time of Linnæus, no material attention seems to have been bestowed upon the subject. . . . . .

"Bergmann, who followed this great master, and also Romé de Lisle, reasoning on a fact imparted to him by one of his pupils, showed how, at least, one species of crystal might be built up of thin laminæ ranged in a certain order, and following certain rules of superposition. He failed, however, in deducing just and general conclusions from this remark, which, correctly viewed, is the foundation of the most important law of crystalography, *that which connects the primitive form with other forms capable of being exhibited by the same substance, by a certain fixed relation.* . . . . .

But "whatever conception we may form of the manner in which the particles of a crystal cohere and form masses, it is next to impossible to divest ourselves of the idea of a determinate figure common to them all. Any other supposition, indeed, would be incompatible with that exact similarity in all other respects which the phenomena of chemistry may be considered as having demonstrated. . . . . .

"That peculiar internal constitution of solid bodies, whatever it be, which is indicated by the assumption of determinate figures, &c., cannot but have an important influence on all their relations to external agents, and accordingly the division of bodies into crystalized and uncrystalized, or imperfectly crystalized, is one of the most universal importance. . . . . . Indeed, there can be little doubt that modifications similarly depending on the internal structure of crystals, will be traced through every department of physics. . . . . .

"From what has been said, it is clear, that if we look upon solid bodies as collections of particles or atoms, held together and kept in their places by the perpetual action of attractive and repulsive forces, we cannot suppose these forces, at least in crystalized substances, to act alike in all directions. Hence arises the conception of *polarity*, of which we see an instance, on a great scale, in the magnetic needle, but which, under modified forms, there is nothing to prevent us from conceiving to act among the ultimate atoms of solid or even fluid bodies, and to produce all the phenomena which they exhibit in their crystalized state, either when acting on each other, or on light, heat, &c. . . . . .

"The mutual attractions and repulsions of the particles of matter, then, and their polarity, whether regarded as an original or a derivative property, are the forces which, acting with great energy, and within very confined limits, we must look to as the principles on which the intimate constitution of all bodies and many of their mutual actions depend.

"These are what are understood by the general term of *molecular forces*. Molecular attraction has been attempted to be confounded, by some, with the general *attraction of gravity*, which all matter exerts on all other matter, but this idea is refuted by the plainest facts."*

* Discourse on Natural Philosophy, Cab. Cyc. pp. 239—245.

"Heat," observes Mrs. Somerville, "appears to have a great influence on the phenomena of crystalization, not only when the particles of matter are free, but even when firmly united, for it dissolves their union and gives them another determination. . . . . .

"All attendant circumstances go to prove, that substances having the same crystaline form must consist of ultimate atoms, having the same figure, and arranged in the very same order; so that the form of crystals is dependent on their atomic constitution. . . . . .

"*Hence it may be inferred, that all substances are composed of atoms, on whose magnitude, density, and form, their nature and qualities depend; and as these qualities are unchangeable the ultimate particles of matter must be incapable of wear—the same now as when created.**

"Crystals formed rapidly are generally imperfect and soft; and M. Bequerel found that seven years of constant voltaic action were necessary for the crystalization of some of the hard substances. If this law be general, how many ages may be required for the formation of a diamond?"†

"Not only do we find," says the writer on heat in the Cabinet Cyclopædia, "proofs that bodies consist of infinitely minute molecules, but we also discover in the effects of crystalization, clear evidence that such molecules in different bodies have different shapes, which shapes are plainly indicated to us by the effects of crystalization, although the particles which effect such forms be so infinitely minute as to elude all means of direct observation, even with the aid which the powers of science can afford to the senses.

"Bodies composed of such particles are found to exist in a great variety of states. . . . . To account for these effects, we must suppose a class of physical agents acting on the component molecules of bodies analogous to those influences with which astronomy and mechanics make us acquainted, and which act on larger masses. By the force of gravitation the masses of the planets and satellites have a tendency to approach each other with definite forces. Electricity and magnetism, in their effects, afford examples of force, both attractive and expansive, exerted by bodies of sensible magnitude one upon another. Analogy, therefore, leads us to expect agents of a similar nature to be exerted between the molecules of bodies, and thus discovers the harmony which reigns among the causes which maintain together the systems of the universe, and those which give coherence and form to the smaller bodies of which those systems are composed."‡

In continuation of these evidences, others have now to be adduced to show, that what thus takes place in the chemical laboratory, has prevailed for ages in the great laboratory of nature, and has produced those vast mineral masses which constitute the outer crust of the earth.

Professor Phillips, in a general way, speaks of the unstratified rocks forming "a universal *crystaline* basis to the stratified rocks," and again, "the stratified rocks which are the products of water rest universally on unstratified crystaline rocks, which, through whatever previous conditions their particles may have passed, have assumed their present characters from the agency of heat."

* 56th Theorem. † Connexion of the Sciences, pp. 125, 127, 312.
‡ Cab. Cyc. vol. xxxix. pp. 186, 187.

A little farther on he adds—

"The *calcareous* portions are somewhat remarkable among limestones for their generally crystaline character. Even the fossiliferous rocks have much of this feature, and all the older beds are really crystalized.

"The case of limestone is soon settled. It is known that, in contact with igneous rocks, the chalk of Ireland and the limestone of Teesdale are turned to crystalized carbonate of lime; and experiments in the laboratory have left no doubt of the propriety of referring this crystalization of the limestone to the mere agency of *heat and pressure*. This high temperature must have pervaded, of course, all the rocks with which the altered limestone is associated. But it occurs with nearly all members of the mica-slate and gneiss systems. All these rocks, then, have suffered the influence of heat. In like manner experimental proof has been offered by the chemist that quartz rock is merely sandstone altered by heat; and thus we find reason to believe that some of the characters by which gneiss and mica-slate approach to granite, are owing to their having experienced considerable influence of heat."

And in conclusion from this geologist, the following summary, adduced by him when referring to some late theories, which endeavour to account for the *transformation into crystaline* material of so great a proportion of the earth's crust:—

"Hence," says he, "as a consequence, we infer the consolidation and many other characters of primary strata, to be the effect of heat; but this falls short of the proof required, which must be to the extent of showing, not the changes of secondary to primary strata, but the changes of these into granite, and other crystaline rocks generally. Satisfactory proof of this nature and to this extent, is, we believe, nowhere afforded."*

The crystaline structure of the igneous rocks is so well known and admitted by all; and the assumption of a transformation having taken place in producing that texture is so general and implicit, that proofs need hardly be multiplied on the subject; I shall therefore conclude with a brief observation from Mr. Lyell: which is the more readily given, not only because he has dedicated so much attention to this particular branch of geology, but in this instance he identifies his own opinion—the result of his labours—with that of another distinguished writer.

"Sir John Herschel," says he, in allusion to slaty cleavage, "has suggested, that if rocks have been so heated as to allow a commencement of crystalization; that is to say, if they have been heated to a point at which the particles can begin to move amongst themselves, or at least on their own axes, some general law must then determine the position in which these particles will rest on cooling. Probably that position will have some relation to the direction in which the heat escapes. Now, when all, or a majority of particles of the same nature have a tendency to one position, that must, of course, determine a cleavage plane. Thus we see the infinitesimal crystals of fresh precipitated sulphate of barytes, and some other such bodies, arrange themselves alike in a fluid in which they float; . . . .

* Treatise on Geology, pp. 69, 70, 75, 76, 259.

and what occurs in our experiments on a minute scale, may occur in nature on a great one."*

The information which has thus been acquired, must now be applied to the more direct chain of the general argument, with a view to discover whether the mineralogical structure of the older rocks affords those *internal* symptoms of having been subjected to the fusing heats which this Theory pre-supposes. It is stated in the *twenty-fourth* Theorem, "*That there exists an essential mineralogical difference between the older crystaline rocks, such as granite, trap, porphyry, serpentine, and others of that age and denomination, considered to be of igneous origin, and those which have been ejected from modern volcanoes distinguished by the name of lavas, a difference attributed to the greater pressure under which the older masses were formed, to the non-action of the atmosphere and consequent retention of their gaseous or volatile parts, and to the more gradual manner in which they have cooled down.*"

This being an important point, which requires to be well authenticated, its evidences will be gone into somewhat in detail.

M. de la Beche enters on the subject at once, but with characteristic caution, when he says—

"If this opinion, of the greater prevalence of the granitic rocks over the trappean at the earliest periods be correct, it would seem to point to a certain condition of things at such periods, which subsequently became so modified that the igneous eruptions became altered. What that condition of things may have been, we do not as yet appear to have any very definite ideas; and we obtain little help on the subject from the phenomena of modern volcanoes, granite never having been known to flow from them. We, however, learn from this circumstance, that igneous eruptions into the atmosphere are not favourable to the production of granites, and we may consequently infer, that the conditions under which granite was produced were not similar to those which we now observe on the surface of the earth; at least so far as relates to those phenomena which occur in the atmosphere. What igneous matter ejected beneath a great pressure of sea may form we are unable to determine, but that it would be greatly modified by such pressure cannot be doubted. . . . . .

"It has been, indeed, generally considered that the mineralogical character of igneous rocks has been changed during the deposit of the stratified rocks, through which they have more or less forced their way; that is, we do not find granite and serpentine flowing from *modern* volcanoes, nor trachite, nor leucitic lavas intimately associated with the oldest strata in such a manner, that their relative differences of age could not be very considerable. . . . . We are compelled, therefore, to admit, that the conditions under which the two kinds of igneous rocks have been formed have not been the same. What these conditions may have been is a separate question, and one, as observed above, requiring investigation; but it will be at once obvious, that the ejection of a mass, in a state of igneous fusion, into the atmosphere, would be likely to have its constituent parts arranged differently from those in a

* Elements, vol. ii. pp. 399, 400, taken from a letter from the Cape of Good Hope, of 20th February, 1836.

similar manner forced out beneath a great pressure, such as we may consider to exist beneath deep seas. Independently, however, of this consideration, there appears to have been something in the condition of the world at the earliest times, causing certain compounds to be formed in great abundance, which does not now continue in such force as to permit the production of similar compounds."*

"If," says Mr. Lyell, "we examine a large portion of a continent, especially if it contains within it a lofty mountain range, we rarely fail to discover two other classes of rocks, very distinct from either of those above alluded to, and which we can neither assimilate to deposits such as are now accumulated in lakes or seas, nor to those generated *by ordinary volcanic action*. The members of both these divisions of rocks agree in being *highly crystaline* and destitute of organic remains. The rocks of one division have been called *plutonic*, comprehending all the granites and certain porphyries, which are nearly allied in some of their characters to volcanic formations.

"The members of the other class are stratified and often slaty, and have been called by some the *crystaline schists*, in which groups are included gneiss, micaceous schist, or (mica-slate), hornblend-schist, statuary marble, the finer kinds of roofing slate, and other rocks afterwards to be described. As it is admitted that nothing strictly analogous to these crystaline productions are now to be seen in the progress of formation upon the earth's surface, it will naturally be asked, on what data can we class them as to origin?"

And again—

"To a certain extent, however, there is a real distinction between the trappean formations and those to which the term volcanic is almost exclusively confined. The trappean rocks, first studied in the north of Germany, and in Norway, France, Scotland, and other countries, were either such as had been formed entirely under deep water, or had been injected into fissures and intruded between strata, and which had never flowed out in the air, or over the bottom of a shallow sea. When these products, therefore, of sub-marine or subterranean igneous action were contrasted with loose cones of scoriæ, tuff, and lava, or with narrow streams of lava in great part scoriaceous and porous, such as were observed to have proceeded from Vesuvius and Etna, the resemblance seemed remote and equivocal. It was, in truth, like comparing the roots of a tree with its leaves and branches, which, although they belong to the same plant, differ in form, texture, colour, mode of growth, and position. The external cone, with its loose ashes and porous lava, may be likened to the light foliage and branches, and the rocks concealed far below, to the roots."†

Professor Phillips appears to take a similar view of this branch of geological research, and to confirm it, when he says—

"But there is yet another form of modern volcanic aggregates which it is of great importance to distinguish from the preceding, because of its bearing upon points of great importance in old geology. There are *subterranean volcanic products* which neither are poured into the sea, nor thrown into the air, but secretly elaborated under the pressure of a solid covering, and effused into the fissures of the rocks.

* Manual, pp. 493, 501. † Elements, vol. i. p. 14, and vol. ii. pp. 232, 233.

"Although it may reasonably be allowed that the great variety of productions ejected by sub-aerial volcanoes affords a good indication of the principal mineral structures generated by volcanic action, we must be cautious not to limit our notions of their combinations in the deep parts of the earth to those which are suggested by the compounds which are determined at the surface.

"The degree of pressure, rate of cooling, and mass of ingredients which are known to be important modifying conditions of *molecular* aggregation, are wholly different at the roots and about the surface of the immense volcanic chimnies which, like Etna and the Peak of Teneriffe, become filled with the liquid rocks whenever the subterranean pressure amounts to a particular degree.

"At the base of a volcanic vent, deep in the earth or under the sea, particular mineral aggregates, slowly cooled, under great pressure, and in great masses, may, and probably do, at this day, assume the large crystaline texture and distinctness of ingredients of granite. On the bed of the sea they may flow in the state of porphyry or basalt; on the surface of the land appear as porous lava, and be blown into the air in disintegrated scoriæ, ashes, and dust."*

* Treatise, pp. 238—240.

SECTION V.

GEOLOGICAL PHENOMENA RESULTING FROM THE EARTH'S PROTOROTATION.

CHAPTER XXII.

The evidences adduced, and the points established in the foregoing chapter, briefly applied. *Firstly.* To explain the enigma of the presence of crystalization arising from both *aqueous* and *igneous* fusion observable in the rocky crust of the Earth. *Secondly.* To account for the existence in the same, of mineral veins and dykes of Granite, Porphyry, Trap, &c. &c. Geological evidences in confirmation of these two branches of enquiry. A few concluding observations.

THE fusion of the injected, amorphous rocks, which everywhere so abound in fields of geological investigation, and the means employed to effect their fusion—as pre-supposed by what has been stated in the foregoing chapters—could scarcely have been better authenticated. The evidences adduced are perfectly conclusive; for, that which ought to have been the result of the application of fierce heat, under the circumstances presumed, having been premised, the experience of geologists, in their researches amongst the same rocky formations, has been adduced, and the two are found closely to coincide; while the wisdom of the method adopted by the Creator has been made most manifest. In contemplating the harmony which, by these two methods of investigation, is seen to prevail, the mind cannot fail to be impressed by the wisdom and goodness which are displayed, as well in the time as in the mode of their execution; and gratified, besides, that science has been the means of revealing these to us. For it appears evident by the two Theorems which have been alluded to,* that the fusion of calcareous rocks is greatly facilitated by pressure, and by exclusion from the air; these conditions serving to retain their gaseous components: and that the same object is likewise attained by their being subjected in great masses to the sudden application of heat; while their gases are bound up and rendered innocuous by union with lime, or by decomposition, the oxygen being set free by the action of plants. Therefore, had this universal and intense fusion of limestone taken place in atmospheric air, and after the formation of the vegetable

* 24th and 101st Theorems.

kingdom, so much carbonic acid would have been evolved, that animal life dependent on pulmonic action could not have existed. But by opportunely choosing the time, and performing the whole in one grand operation, all these requisite *conditions* being foreseen, were duly provided for! By the evolution of the heat *beneath* the primeval waters, and before the formation of the atmosphere and the vegetable kingdom, the otherwise noxious gases were rendered beneficent, and subservient to the future wants of man; the same provident forethought being ever present in all the works of the Creator. By this we are, likewise, supplied with a striking corroboration of the exactness of the epoch, assigned by the inspired historian, as that of the elevation of the continents and mountains of the earth, *from its having taken place beneath the pressure of the ocean, and while as yet there was no atmosphere.*

The application of these conclusions may assist to unravel one of the greatest enigmas attending geological research. I allude to the evidences existing in the rocky masses, which lead to the undeniable conclusion, that crystalization, both by *aqueous* and *igneous* means, has been employed in their formation—a fact, which, to account previously for, seemed to require, that recourse should be had to probabilities which could scarcely be conceded. But by this it can be clearly perceived, that *aqueous* crystalization was employed to aid in forming these masses in a horizontal position before the earth was made to rotate; *igneous* crystalization, arising from fierce heat occasioned by friction, having been afterwards evolved to complete their structure, when they were simultaneously raised from that recumbent posture by the first diurnal movement of our sphere; while it is obvious that as this latter crystaline structure is the effect of heat; and heat, in the instances alluded to, arose from friction; and these, in turn, were occasioned by the general movement, *inter se*, of the mineral masses composing the crust of the globe, then the ultimate result—crystalization—would be at its maximum amongst the more elevated and more disturbed formations; those which travelled farthest from horizontality having undergone greatest fusion, and consequently evolved most heat. These natural and unconstrained conclusions supersede the necessity of recurring to supposed sudden and capricious transitions from one description of crystalization to another; and while they remove this difficulty, they reveal the cause of those phenomena which intrude themselves so strongly upon the notice of geologists in these departments of their research.

What has now been said has also sufficiently proved, that *violent movement did take place* during the epoch referred to, amongst those masses of mineral matter which now constitute the rocky formations of the earth's surface; as shown by the local fusion, which was the immediate consequence; and that, therefore, the foci of heat resided in the centres of motion, that is, in the highest elevations.

It must, also, be obvious, that if these rocks, so circumstanced,

were impelled by the centrifugal impetus with so much force as to elevate the superincumbent strata; veins, or branches of the fused material, should be found not only insinuating themselves into the crevices formed by the strata, where they were shook and distorted by the general commotion; but, likewise, that these streams of fused mineral should be discovered to have burst through and overcome every obstacle, when the superincumbent masses did not separate so as to permit them to pass. On referring to the facts which have been brought to light by the investigations of geologists, it is discovered, that rocky protrusions, called veins and dykes, of the description and character here anticipated, are frequently found intersecting the whole series of formations, from the primary to the surface inclusive. But let geology speak for itself. The *twenty-ninth* Theorem, and its accompanying evidences, state, "*That when a view is taken of any geological map, it is observed that the formations represented by it are intersected by veins of granite, porphyry, senite, trap, serpentine, greenstone, &c., and by dykes of similar material, especially of trap and basalt. That whatever may be the nature or position of the formations through which they pass, the general direction of the main trunks of these veins and dykes is perpendicular to the earth's surface, although their branches frequently diverge and weld the several formations together in a remarkable manner. And that overlying masses of the same materials are frequently found on the surface, as if they had overflown from the veins while in a state of fusion.*"

"Within the primary granite," says Professor Buckland, "we find other forms of granitic matter, which appear to have been intruded in a state of fusion, not only into older fissures of the older granite, but frequently also into the primary stratified rocks in contact with it, and occasionally into strata of the transition and secondary series. These granitic injections were probably in many cases contemporaneous with the rocks they intersect; they usually assume the condition of veins, terminating upwards in small branches; and vary in dimensions from less than an inch to an indefinite width. The direction of these veins is very irregular; they sometimes traverse the primary strata at right angles to their planes of stratification, at other times they are protruded in a direction parallel to those planes, and assume the form of beds.

"Closely allied to granitic veins, is a second series of irregularly injected rocks, composed of senite, porphyry, serpentine, and greenstone, which traverse the primary and transition formations, and the lower regions of the secondary strata; not only intersecting them in various directions, but often forming overlying masses in places where these veins have terminated by overflowings at the surface. The crystaline rocks of this series present so many modifications of their ingredients, that numerous varieties of senite, porphyry, and greenstone occur frequently in the products of the eruptions from a single vent. . . . . .

"A third series of igneous rocks, is that which has formed dykes, and masses of basalt and trap intruded into and overlaying formations of all ages, from the earliest granites to the most recent tertiary strata. These basaltic rocks sometimes occur as beds, nearly parallel to the strata into which

they are intruded, after the manner represented in the carboniferous limestone of our section. More frequently they overspread the surface-like expanded sheets of lava."*

"The last circumstance," Dr. M'Culloch states, "in the geological character of granite, relates to its distribution in the form of veins, of which there are two distinct kinds. The first lie wholly within the rock, consisting of the same materials, under slight differences in the colour and magnitude of the parts, being also connected with similar variations, of a concretionary appearance without the veinous form. . . . . . The next are much more interesting, and constitute the principal arguments respecting the posteriority of granite to the strata with which it is associated. These vary infinitely in their dimensions, extent of course, entanglement, and ramifications. At times they are rather protuberances from the general mass than veins, while at others they extend to great distances, insinuating themselves widely into the surrounding strata, above all, in gneiss, in which rock also they especially abound. Thus, also, their thickness varies, from many yards, even to the minuteness of a thread, being simple or ramifying; and often also presenting the most intricate reticulations. In composition, the larger veins, at least, sometimes, resemble the purest mass, while, in the smaller, the structure often becomes minute, as if proportioned to the size of the vein. But more commonly, the materials are crystalized on a much larger scale, producing the well known specimens of felspar and mica, as, in these veins also, the accidental minerals enumerated in the classification are chiefly found. Yet the size of the ingredients does not bear a proportion to that of the vein; the larger crystalizations as often occurring in the small as in the large ones."†

"Thus far," says M. de la Beche, "we have only seen granite rising through and covering other rocks in considerable masses, but we have also evidence in granite veins, that the matter of the rock was in such a state of igneous fusion, as to penetrate into thin clefts opened in stratified and older rocks, by some violence, such as probably resulted from the upburst of igneous matter accompanied by elastic vapours. . . . . . Glen Tilt, which produced such delight to Hutton when viewed by him for the first time, presents excellent examples of the intrusion of granite veins into other and stratified rocks. . . . . . Granite veins traversing the stratified rocks are now known in various parts of the world. . . . . . Granite veins, therefore, cannot be considered as rare; on the contrary, they would appear sufficiently common, when circumstances permit good sections of the junction of the granitic mass, and of the rocks among which they appear intruded. . . .

"The exact composition of the granite in these veins must necessarily vary, depending much on local circumstances, for if we suppose a substance in igneous fusion to be injected into fissures of rocks, such injected matter will be subjected to different conditions. Where the fused substance cooled more suddenly, as was likely to be the case in the distant and smaller fissures, the result would be less crystaline; while in the wider clefts, and near the great heated mass, the crystalization would be more perfect, and bear the greatest resemblance to the parent mass. Consequently, in a system of granite veins, we would expect a great diversity in the aspect of the granitic matter, which generally appears to be the case.

* Bridgewater Treatise, vol. ii. pp. 4—6.

† Geology, by Dr. M'Culloch, vol. ii. pp. 95, 96.

"The trappean rocks, though there is much difficulty in separating them from the granitic, may, for convenience, be considered separately from them. They also form considerable masses, and constitute dykes and veins.

"Under their various modifications, they are so common in nature, that to attempt a notice of localities would be entirely useless. They occur mingled with the stratified rocks in every possible way; injected among the beds for considerable distances; . . . . . constituting caps of hills; . . . . . or as dykes and veins filling fissures. . . . . . Trap dykes are to be found in all parts of the world, the composition of the rock varying materially, even in the dyke itself, as we might expect from differences in the cooling and pressure, so that the central parts are not unfrequently more crystaline than the sides. . . . . .

"The above is sufficient to show, that trap, under certain conditions, may pass into serpentine. We have now to consider dykes and masses of serpentine and diallage rock, which occur under circumstances analogous to those of the trap rocks, &c. &c.

"If we regard these igneous products as a mass of matter which has successively, and during the lapse of all that time comprehended between the earliest formation of the stratified rocks and the present day, been ejected from the interior of the earth, we shall be struck with certain differences of these rocks on the great scale, which has led to their practical arrangement under the heads of granitic, trappean, serpentinous, and volcanic products as above noticed."*

"Few parts of the globe," says Professor Phillips, "except some of its vast plains and deserts, are entirely deficient of rocks which are not stratified, though the surface which they occupy is not nearly so great as that covered by the strata. Granitic and basaltic rocks compose, generally, the greater portion of the unstratified masses, as in Britain, and lie in the same relations to the strata. For granitic rocks, throughout the globe, are the most frequent axes or centres of mountain groups, and basaltic rocks fill dykes and spread in irregular cappings over the strata. It is evident, therefore, that the structure of the exterior parts of the globe, though full of local diversity, is all formed upon one general plan, and produced by similar agencies." . . . . . And again—"In Northumberland, Cumberland, and the Northern part of Yorkshire, a stratiform mass of greenstone and basalt (whin-sill) is interposed in the midst of the limestone series, apparently originating in several submarine lava currents. In Derbyshire, a somewhat analogous rock, 'toadstone,' interlaminates the limestone; in the Clee Hill, a mass of basalt, 'jewstone,' has overflowed the coal. More commonly, throughout all the coal-fields of Durham and Newcastle, and not unfrequently in the coal-basins of Scotland, rocks of the same kind have been injected in the fluid state into open fissures of the sandstones and shales, constituting dykes."†

"When," says Mr. Lyell, "geologists first began to examine attentively the structure of the northern and western parts of Europe, they were almost entirely ignorant of the phenomena of existing volcanoes. They found certain rocks, for the most part without stratification, and of a peculiar mineral composition, to which they gave different names, such as basalt, greenstone, porphyry, and amygdaloid. All these, which were recognized as belonging

* Manual, pp. 491—494, 496, 498, 500.

† Treatise on Geology, pp. 42, 110.

to one family, were called 'trap,' by Bergmann, from *trappa*, Swedish for a flight of steps, a name since adopted very generally into the nomenclature of the science; for it was observed, that many rocks of this class occurred in great tabular masses of unequal extent, so as to form a succession of terraces or steps on the sides of hills." And again—"Fissures have already been spoken of as occurring in all kinds of rocks, some a few feet, others many yards in width, and often filled up with earth or angular pieces of stone, or with sand and pebbles. Instead of such materials, suppose a quantity of melted stone to be driven or injected into an open rent, and there consolidated, we have then a tabular mass, resembling a wall, and called a trap dyke.

"As fissures sometimes send off branches, or divide into two or more fissures of equal size, so, also, we find trap dykes bifurcating and ramifying, and sometimes they are so tortuous as to be called veins, though this is more common in granite than in trap. . . . . .

"In the Hebrides and other countries, the same masses of trap, which occupy the surface of the country far and wide, concealing the subjacent stratified rocks, are seen, also, in the sea cliffs, prolonged downwards in veins and dykes, which probably unite with other masses of igneous rock at a greater depth. The largest of the dykes represented in the annexed diagram (all vertical or nearly so), and which are seen in a part of the coast of Skye, is no less than 100 feet in width. Every variety of trap rock is sometimes found in these dykes, as basalt, greenstone, felspar, porphyry, and more rarely trachyte. . . . . .

"Some dykes of trap may be followed for leagues uninterruptedly in nearly a straight direction, as in the North of England, showing that the fissures which they fill must have been of extraordinary length.

"A striking example," he continues, when instancing the alteration effected by these dykes, "near Plas Newydd, in Anglesea, has been described by Professor Henslow. The dyke is 134 feet wide, and consists of a rock which is a compound of felspar and augite. Strata of shale and argillaceous limestone, *through which it cuts perpendicularly*, are altered to a distance of 30, or even, in some places, to 35 feet from the edge of the dyke. . . . . .

"As examples might be multiplied without end, I shall merely select one or two others, and then conclude.

"The rock of Stirling Castle is a calcareous sandstone, fractured and forcibly displaced by a mass of greenstone, which has evidently invaded the strata in a melted state. . . . . . The secondary sandstones of Skye are converted into solid quartz in several places, where they come in contact with veins or masses of trap; and a bed of quartz,' says Dr. M'Culloch, 'found near a mass of trap, among the coal strata of Fife, was, in all probability, a stratum of ordinary sandstone, having subsequently been indurated and turned into quartzite, by the action of heat."*

"The coal measures," observes Mr. Miller, in one of his happy moods of description, "present often the appearance of vast lakes frozen over during a high wind, partially broken afterwards by a sudden thaw, and then frozen again. Take as an instance, the scenery about Edinburgh. Its striking forms illustrate happily the operations of the great agencies on which, in the secondary and transition deposits, all the peculiarities of scenery depend.

* Elements, vol. ii. pp. 186, 212—216, 219, 220, 223, 224.

The molten matter from beneath seems to have been injected, in the first instance, through rents and fissures among the carboniferous shales and sandstones of the district, where it lay cooling in its subterranean matrices, in beds and dykes, like metal in the moulds of the founder; and the places which it occupied must have been indicated on the surface, but by curves and swellings of the strata. The denuding power then came into operation in the form of tides and currents, and ground down the superincumbent rocks. The ejected masses, now cooled and hardened, were laid bare; and the softer frame-work of the moulds in which they had been cast was washed from their summits and sides, except where long ridges remained attached to them in the lines of the current, as if to indicate the direction in which they had broken its force. . . . . . The outlines of the landscape were modified yet further by the yielding character of the basement of sandstone or shale on which the plutonic beds so often rest. The basement crumbled away as the tides and waves broke against it. The ejected beds above the undermined in this process, with a vertical cleavage, induced by their columnar tendency, fell down in masses that left the front perpendicular as a wall. Each bed came thus to present its own upright line of precipice; and hence, when they rise bed above bed, as often occurs, the stair-like outline of hill to which the trap-rocks owe their name; hence the outline of the Dalmahoy Crags, for instance, and of the southern and western front of Salisbury Crags." . . . . .

And somewhat farther on he resumes—

"Mark now the geology of the ravine of Eathie. The ravine itself may be described as a fault in the strata; but here is a fault, lying at right angles with it on a much larger scale: the great conglomerate on which the triple bars rest has been cast up at least two hundred feet, and placed side by side with them. And yet the surface above bears no trace of the catastrophe. Denuding agencies of even greater power than those which have hollowed out the cliffs of the neighbouring coast, or whose operations have been prolonged through periods of even more extended duration, have ground down the projected line of the upheaved mass to the level of the undisturbed masses beside it. Now, mark further, as we ascend the ravine, that the grand cause of the disturbance appears to illustrate, as it were, and that very happily, the manner in which the fault was originally produced. The precipice over which the stream leaps at one bound into the mossy hollow, is composed of granitic gneiss, and seems evidently to have intruded itself with much disturbance, among the surrounding conglomerate and sandstones. A few hundred yards higher up the dell, there is another much loftier precipice of gneiss, round which we find the traces of still greater disturbance; and higher still, yet a third abrupt precipice of the same rock. The gneiss rose, trap-like, in steps, and carried up the sandstone before it in detached squares. Each step has its answering fault immediately over it; and the fault where the triple bars and the conglomerate meet is merely a fault whose step of granitic gneiss stopped short ere it reached the surface."*

These passages, taken from the works of some of the most scientific of our geological writers, will have sufficiently explained what is meant by *dykes* and *veins*, and have exhibited the characters of

* Old Red Sandstone, pp. 244—246, 256—258.

mineral protrusions: but *geological maps* on sectional principles* can alone make completely evident, at one view what is more especially desired to be impressed, at present, on the mind, namely, the *general direction* which these igneous injections appear to have taken, as they came upwards to burst forth and to overflow upon the land.

Without taking into account the veinous ramifications or more minute inflexions, their course, wherever it has been practicable to examine this continuously, seems to be *nearly perpendicular to the surface.* Without any intention to assert, that these protrusions proceed from or reach the centre, it is merely meant that a parallel straight line passing down the *main trunk* of trap or basalt dykes, and prolonged *imaginarily* would converge, until they all met in one common centre—the centre of the earth.

Now, it must be obvious, that upon a surface so diversified by elevations and depressions, or, in other words, so *uneven* as that of the earth, where the depth subjected to geological examination is so insignificant when compared with the radius, and when it is considered, that the researches which have revealed these igneous protrusions, and have led to the construction of those sectional maps, have been made in some of the least level parts of the earth's surface—the natural inference to be drawn from these combined circumstances is, that no *single* cause could have occasioned any mineral matter, in a state of fusion, to have observed so uniform a direction on such a diversified surface throughout the whole of a spherical body.

The origin of this *uniformity* of *course* must be sought for, not in one, but in a combination of causes, which, unitedly, may be considered commensurate with the effect.

The origin of that which, while it is everywhere the same on the surface of a spherical body, and affords symptoms of having travelled thither, must be looked for towards the centre; and, moreover, the imaginary prolongation of these trappean and basaltic dykes point in the same direction. Nevertheless it is denied that there resides at the earth's centre any adequate cause or power which could have sent forth these streams of melted mineral; a denial which will appear more just, after having perused the observations which immediately follow.

While the necessity is acknowledged of looking *towards* the centre for an effect which is everywhere alike on the surface, and while, at the same time, the centre itself of the earth is set aside as the site of the common cause; and, in lieu thereof, it is considered that the centrifugal impetus, arising from the protorotation of the earth,

* Such as that constructed by Professor Buckland, and appended to his valuable work, the "*Bridgewater Treatise;*" the views in the several works quoted, and above all, Mr. Knipe's Geological Map of Great Britain and Ireland, and part of France, where these dykes and veins are admirably pourtrayed.—AUTHOR.

has been the *prima causa* of these protrusions; yet it is believed, that neither could centrifugal impetus alone have given direction to them. Streams of melted mineral matter proceeding *solely* from, or what is equivalent, in straight lines from an axis of gyration, which *extended the whole diameter of the earth, must have cut the concentric shell in degrees of obliquity, according to their parallels of latitude.* This, had it taken place, would neither have fulfilled the design which the Creator had in view, nor have caused the protrusions to run in the direction in which they are seen by geologists actually to do. The same difficulty will be felt, even should there be added to the above position, the fact of the upheaving or tilting, out of horizontality, of the strata by the same centrifugal force; as it will appear evident, after a little reflection, that veins proceeding in perpendicular lines from the common radius of gyration, the axis of the earth, would (in this latter case) have cut the strata, especially those within the tropics, in directions nearly parallel to the upheaved posture which their lines of stratification had then assumed.

By this theory it has always been maintained, that the first rotation of the earth around its axis occasioned a sudden, violent, aud general movement among the various masses of mineral matter which at that time composed its concentric rocky crust, and, as a natural result of this movement, *inter se,* the evolution by means of friction, of *intense heat;* and it is when we come to investigate into the *origin* and *direction* of these dykes and other *mineral protrusions,* that more than ever is recognized the soundness of these assumptions. Without *movement amongst* the stony materials of the earth's original shell there could have been no *heat;* without *heat* there would have been neither dykes, veins, nor other overflowings of fused mineral matter. Their *mere existence,* therefore, testifies to the fact of those fierce heats having been engendered. Whilst the *direction they have pursued* not only affords evidence to the same effect, but shows that the *expanding influence of heat* co-operated with the *centrifugal force* in constraining them to *adopt a course somewhat between the two, and towards the surface from every centre of heat,* or, what is the same thing, *from every mountain range,* and thus there was conferred upon them that remarkable coincidence of direction throughout all varieties and inequalities of surface, which *no single force* could have caused them, under any circumstances whatever, to have pursued.

From what has been said it must appear evident, that any attempt to have explained the origin and direction of these *mineral protrusions* without reference to centrifugal impetus, would have been as unsuccessful as, on the other hand, any endeavour to have accounted for them by *that force alone,* would have been unsatisfactory and inconclusive. Their existence and their geological position are alike due to that inevitable modification of the centrifugal force, which

was caused by the heat which that motion engendered. When it raised the heat which melted the mineral matter, it likewise propelled the whole towards the periphery; and these together constrained the streams of fused material to find the nearest vent at the surface, as so many outlets for the extension of the matter which an increase of volume, attendant on that of temperature, had occasioned on the earth's crust; whilst the Creator, by his wisdom and power, made use of all these concomitant circumstances to weld the shattered fragments of the earth's outer crust securely together in the very midst of its convulsions, and to bind stratum to stratum, and rock to rock, in the most perfect and enduring manner by a universal protrusion of veins and dykes, which, after perforating the whole, were clenched and rivetted by their overflowings on the surface—the mineral bolts and bars of the earth's outer crust! These veins and dykes also afford other undoubted indications. They show, in the most undeniable manner, whereabouts the surface of the earth then was; for, as long as they had to perforate rocky masses, they proceeded in straight lines, generally speaking, under the combined influence of a superior force, and the opposition which the perforated masses, by their density, offered to their lateral dispersion; but so soon as they reached the surface, or the looser materials of the more recent deposits, having no longer impenetrable substances on each side to confine them, they spread out and around in obedience to the joint laws of gravity and centrifugal impetus; the latter inducing them to overflow, the other causing the ejected mass to fall down by its own weight: hence we are authorised to conclude, that wherever accumulations of fused rocks are found, the surface either was there at the time of the earth's first rotation, or there were present only materials of less density than the overflowing masses, amongst which they conducted themselves almost as they would have done upon the altogether external surface of the forming continents; while the abrading influence of the primitive ocean, as it simultaneously rushed from the polar regions towards the equator, to complete the static condition of liquidity under rotation, would greatly contribute, by its denuding effects, to render the rocky protrusions more prominent, and leave around those impervious barriers incontestable traces of the path which it hurriedly followed, as it swept past them in its impetuous course.

SECTION V.

GEOLOGICAL PHENOMENA RESULTING FROM THE EARTH'S PROTOROTATION.

CHAPTER XXIII.

FAULTS or FISSURES described. Geological evidences of their existence. Application of these data to the COAL MEASURES, considered to have been the uppermost strata of the Non-rotatory Sphere. Found to correspond. METALLIC VEINS, described; geological and other scientific data descriptive of these interesting portions of the rocky crust of the earth.

HAVING thus been enabled to indicate the probable origin of the *mineral veins* which proceed in directions from the centre towards the circumference, I shall in this chapter endeavour to explain, as far as the Dynamical Theory will enable me, whence those called "fissures" or "faults," which proceed in a contrary direction, or from the surface towards the interior of the earth's crust, have arisen. They are taken notice of in the *thirtieth* Theorem, and its accompanying evidence, which state, "*That two distinct classes of mineral veins are found to exist in the earth's outer crust—one of which proceeds from inwards outwards, having their bases in the interior, and their apici nearest to the surface; and the other, termed Faults and Fissures, proceeding from outwards inwards, with their apici in the interior, and their bases on or near to the surface.*"

"In our last chapter," says Professor Buckland, "we considered the advantage of the deposition of the carboniferous strata being in the form of basins. It remains to examine the further advantages that arise from other disturbances of these strata by *faults* or *fractures*, which are of great importance in facilitating the operations of coal mines. . . . . . The component strata of a coal field are divided into insulated masses, or sheets of rock, of irregular form and area, not one of which is continuous in the same plane over any very large district; but each is usually separated from its next adjacent mass by a dam of clay, impenetrable to water, and filling the fissure produced by the fracture which caused the fault.

"If we suppose a thick sheet of ice to be broken into fragments of irregular areas, and these fragments again united, after receiving a slight degree of irregular inclination to the plane of the original sheet, the re-

united fragments of ice will represent the appearance of the component portions of the broken masses, or sheets of coal measures we are describing. The intervening portions of more recent ice, by which they are held together, represent the clay and rubbish that fill the faults, and form the partition walls that insulate these adjacent portions of strata which were originally formed, like the sheet of ice, in one continuous plane. Thus, each sheet, or inclined table of coal measures, is enclosed by a system of more or less vertical walls of broken clay, derived from its argillaceous shale beds, at the moment at which the fracture and dislocation took place; and hence have resulted those joints and separations which, though they occasionally interrupt at inconvenient positions, and cut off suddenly the progress of the collier, and often shatter those portions of the strata that are in immediate contact with them, yet are, in the main, his greatest safeguard, and are, indeed, essential to his operations."*

"The immense violence," observes Professor Playfair, "which has accompanied the formation of mineral veins, is particularly marked by the *slips* and *shifts* of the strata on each side of them, all tending to show that mighty changes have taken place in those regions which our imagination erroneously paints as the abode of silence and rest. . . . . Mineral veins contain abundant marks of the most violent and repeated disturbance. And it appears most likely, that fissures in the strata were made, at least in many instances, and the matter poured into them, nearly at the same time, both being effects of the same cause,—the expansive force of subterraneous heat. . . . .

"If all these circumstances are put together, there appears but one conclusion to be drawn from them. The manifest marks of some power which could lift up fragments of rocks from their native places, distant several hundred yards from their present situations; place them upright on their edges, encompass them with solid rock quite heterogeneous to themselves, and bestow upon them a great addition of solidity and induration.

"It is indeed, impossible, that the effects of motion and heat can be more clearly expressed than by these symptoms; or the subject in which these powers resided, more distinctly pointed out."†

"Faults," according to Mr. Conybeare, "consist of fissures, traversing the strata, extending often for several miles, and penetrating to a depth in very few instances ascertained; they are accompanied by a subsidence of the strata on one side of their line, or (which amounts to the same thing) an elevation of them on the other; so that it appears, that the same force which has rent the rocks thus asunder, has caused one side of the fractured mass to rise, or the other to sink. The fissures are generally filled by clay."‡

"As we can scarcely conceive such a general and simultaneous movement of the inferior strata," says M. de la Beche, when treating of the red sandstone group, "immediately preceding the first deposits of the red sandstone series, that every point on which it reposes was convulsed and threw off fragments on the sudden elevation of lines of strata, we should rather look to certain foci of disturbance for the dispersion of debris. The accumulation of the larger fragments, and the relative amount of conglomerate, would, under this hypothesis, be greatest nearest to the dis-

* Bridgewater Treatise, vol. i. pp. 541—544.
† Illustrations of Huttonian Theory, Playfair's Works, vol. i. pp. 76, 258, 301.
‡ Geology of England and Wales, part i. p. 348.

turbing cause; and amid such turmoil we might anticipate the occurrence of igneous rocks thrown up at the same period. . . . . Indeed, there is every reason to consider that the eruption of trap rocks did accompany (if partly not produce) the disruption of strata, whence the fragments in the conglomerate were derived: for we have seen that red quartziferous porphyry, in mass, surmounts a portion of the red conglomerate; and the occurrence of trappean rocks so blended with the conglomerates that lines of separation cannot be drawn between them. Now, if igneous rocks were ejected, a conclusion which the facts appear to justify, at the time of the production of the conglomerate, there would seem no reason why, under favourable circumstances, the two should not be in some measure blended with each other. Another circumstance also lends probability to this view, and that is, the occurrence of pebbles cemented in certain inferior beds by a kind of semi-trappean paste, containing crystals of that variety of felspar named murchisonite by Mr. Levi. Such a cement might possibly have resulted from the upburst of igneous rocks, accompanied by various gases beneath a mass of water, when some of the erupted matter may have so combined as to form a cement, in which crystals of murchisonite became developed: without some such hypothesis this cement seems of very difficult explanation."*

"Numerous rents may often be seen," says Mr. Lyell, "in rocks which appear to have been simply broken, the separated parts remaining in the same places; but we often find a fissure, several inches or yards wide, intervening between the disunited portions.

"These fissures are usually filled with fine earth and sand, or with angular fragments of stone, evidently derived from the fracture of the contiguous rocks.

"It is not uncommon to find the mass of rock on one side of a fissure thrown up above, or down below, the mass with which it was once in contact on the other side. This mode of displacement is called a shift, slip, or fault."†

"In some cases," says Professor Phillips, "instead of acclinal or declinal slopes to or from an axis, we have a complete *fracture* of the mass of strata along a vertical or inclined plane, parallel to which the beds one on side are uplifted, and on the other depressed. This is called a *fault* or *slip;* almost every coal district and mining region in the world is full of such, though their number is, upon the whole, very much greatest in elevated districts, and least in the youngest strata.

"The extent of displacement on one side of such fault is sometimes only a few inches; in other cases 10, 100, or 1,000 feet or yards. The great Craven fault and Cross Fell fault in the North of England is complicated with a narrow anticlinal axis, the extent of displacement produced by both is 1,000, 2,000, 3,000, or even 4,000 feet (Diagram, No. 7).

"The jointed structure of rocks of the carboniferous system has been minutely investigated. In the Geology of Yorkshire, vol. ii., it is shown, from eighty-five observations in the carboniferous system, that in the mountain limestone and coal tracts of Yorkshire, the *long joints* affect certain principal directions, so that two positive axes, in which these divisional planes are most frequent, are traced at right angles to one another; and two negative axes in which *no* long joints have been observed, also at right angles to each other.

* Manual of Geology, pp. 403, 404.

† Elements, vol. i. p. 128.

"The axes of frequent joints run N.N.W. and S.S.E., and E.N.E. and W.S.W., the negative axes are N.E. by N., and N.W. by W. This singular result of observation harmonizes with the principal directions of mineral veins in the district bordering on the Great Cross Fell and Craven faults; it also bears a close analogy with the deductions from the mechanical theory of Mr. Hopkins (Cambridge Trans., 1836), as to the production of planes of fissures, at right angles to each other, in cases of continuous pressure being applied to large areas of the earth's lamellar crust.

Magnitude of disturbance.—The extent of the dislocations effected by particular convulsions is really enormous, and puts to shame the utmost exertion of a succession of modern earthquakes for many thousands of years. The Penine region of the north of England, elevated posterior to the era of the coal measures is defined on three sides by dislocations of 1,000, 2,000, 3,000, and more feet; and there is, perhaps, as little reason to suppose that more than one effort was employed on any one of these sides, as in the case of an ordinary fault! Such faults, indeed, sometimes occasion depression of several hundred feet; but seldom for such great lengths as the Penine and Craven disturbances."*

If we imagine the surface of a level sphere enveloped, in certain portions of its area, by concentric and alternating strata of coal and clay, or shale, in a semi-indurated condition, and then suppose that, by a sudden revolution, it is greatly enlarged—and this enlargement is filled up by the protrusion of amorphous rocks among its stratified masses, whereby great elevations and depressions are caused upon its surface—the origin of these *fractures* or *faults*, in the secondary strata, will be recognised at once. Indeed, there is no other way in which the coal measures, then partially constituting the surface of our globe, could possibly have accommodated themselves to a simultaneous enlargement of surface, and to a change of inclination. They must unavoidably have been rent and split into detached portions, in precisely the same manner as a bed of clay now becomes when it contracts by drought and heat, and then is too small to extend over the surface which it formerly covered; with this difference, however, that in the one case the clay alone contracts; while, in the other, the surface became enlarged, at the same time that the clayey formations did, to a certain extent, contract.

It must likewise be obvious, that the fissures or spaces thus occasioned between the cuboidal masses of coal, clay, sandstone, &c., could not be entirely filled up by material derived from the alternating shale beds of the carboniferous series themselves, because there is no way whereby a determinate quantum of strata, which once covered a certain extent of area, could be made to cover a greater extent of surface, unless by spreading out, or what is the same, by undergoing a corresponding reduction in vertical thickness; but as this has never been even dreamt of by any one, it follows, that the original quantum of matter, having maintained

* Treatise, pp. 62, 63, 107, 108, 260, 261.

its previous thickness, could not, *from its own body*, supply the void occasioned by the enlargement of surface. Clay from the shale beds may, and no doubt did, filter in along with other matter from above; but for the reasons assigned, it must have been to a limited extent. On the other hand, a ready and satisfactory solution of the question will be found, if the matter contained in these partitions be attributed to enfiltration from above, while the surface of the earth (although rotating) was as yet submerged in the primeval ocean. At the time of its first rotation the waters were surcharged, as will be shown presently, with mineral *debris* of all kinds; and these, in rushing in to fill up the chasms caused by the enlargement of the earth's surface would carry in a portion of their mineral contents along with themselves, and thus charge them with a mixture of "clay and rubbish," which, by afterwards becoming indurated, formed those useful, though sometimes embarrassing, compartments into which the secondary strata, and especially the coal fields, are found so frequently to be divided.

This view of the subject explains, likewise, the cause of these cuboidal masses being higher on one side of the fault than the other. For this is precisely the position in which masses of that form, if free to move, would arrange themselves, when raised up from a horizontal position, and made to lie upon an inclined plane, *provided the spaces between them were filled with a substance of so soft a consistency as to offer no opposition to their movement.* This, besides, is the *only* way in which the phenomena attendant on these faults, and inter-contained cuboidal masses can be thoroughly explained; for, *there is no direction, in which any mass injected from beneath—supposing this to be the cause of the dislocation—could have raised up the strata on the one side and depressed them on the other.* If, on the other hand, the cause is presumed to have acted *from above downwards*, the corresponding depression must have been equal on either side of the downwardly intruded mass: therefore, the force which occasioned these phenomena must have been *general*, occasioning a universal elevation of individual masses, and a corresponding relative inequality of level, or apparent depression between any two of their nearest edges. Cuboidal masses of equal thickness laid upon an inclined plane would assume a relative position to each other, precisely in accordance with that which those forming the coal fields are found to do. These considerations, the legitimate offspring of the Dynamical Theory, also tend to reconcile the conflicting opinions as to the *aqueous* or *igneous* origin of veins, by showing, that there may exist veins proceeding from both causes, easily to be accounted for when looked upon in the light with which they are here viewed, although resisting a cordial reconciliation when they are wholly attributed to any *one* of these causes.

Finally. From all that has been said on this branch of the subject, it appears evident, *that the dislocations and corresponding faults*

in the secondary strata were occasioned by the rotation of the earth around its axis, while yet its whole surface was under water; that is, at some period between the FIRST *and the* THIRD *days of the Mosaic week.*

We have, in continuation, to consider a third and distinct class of veins found intersecting the earth's outer crust, and whose origin is involved in considerable obscurity. I allude to the METALLIC VEINS. It is presumed, however, that the Dynamical Theory, by having made so manifest the existence of distinct centres or foci of heat, while it has explained the origin of the other two classes of veins and fissures, may, happily, be capable of also throwing some light upon these arcanæ of the creation. Yet it is necessary to premise, that in attempting this, there will be occasion to make direct allusion to mineralogical and geological discoveries and conceptions, which, although they afford bright and vivid glimpses into these secret recesses of nature, are still incomplete and immature, and, therefore, it is expected that every reasonable allowance will be made, should what there is to say on this subject amount only to well-grounded probabilities, pointing the way to the confirmation hereafter of these surmises, when their attendant circumstances shall have become more fully developed.

The following are the Theorems which refer to these veins. The *hundred-and-fifth* Theorem states, "*That* METALLIC ORES—*which are metals in combination either with sulphur, charcoal, oxygen, and even with other metals, or with silica, alumina, and lime—are commonly found in narrow fissures, termed lodes or veins, predominating in the primitive and transition series, and which are usually filled up with some crystaline mineral different from the rock in which they occur.*

"*That they are supposed to have been produced by electrical agency developed by the violent contact and friction of rocks of various kinds, containing, previously, metalliferous elements. And, that the same lode frequently contains a metallic pyrite, and, within a short distance, separated merely by a common argillaceous substance, some other modification of the same metal, whilst the lode itself is generally saturated with water containing various salts.*"

Considering the fact of the *mere existence* of these veins to be too well authenticated to require any further evidence, I go on to enquire into their *direction*, and other *conditions*, which are much more essential to the establishment of the present subject. For this purpose, reference is made to the Theorem which follows the one just given, wherein it is stated, "*That when a general view is taken of* METALLIC VEINS *on any geological map,* * *the following prominent and characteristic features present themselves to the observation, namely:—*

"1. *That they either entirely originate from, or predominate in, the primary masses and the transition series.*

* The geological maps here alluded to are those displaying sectional views of the various formations, veins, &c., such as those constructed by Dr. Buckland, Mr. Lyell, Mr. Knipe, and others.

"2. *That, generally, they run in straight lines, and in directions oblique to the surface; veins of different materials cutting each other at right angles, and, not unfrequently, perpendicular to the lines of stratification.*

"3. *That, unlike faults and dykes, mineral veins do not cause dislocation of the strata; but seem, whilst they have evidently passed through, to have left them undisturbed in their relative positions. And*

"4. *That when veins cut each other at right angles, they are usually different in their contents.*"

"Metallic veins," says Professor Buckland, "are of most frequent occurrence in rocks of the primary and transition series, particularly in those lower portions of stratified rocks which are nearest to unstratified crystaline rocks. They are of rare occurrence in secondary formations, and still more so in tertiary strata."

In a note he adds—

"Mons. Dufrenoy has recently shown that the mines of Hæmatite and Spathic iron in the Eastern Pyrenees, which occur in limestones of three ages, referable severally to the transition series, to the lias, and to the chalk, are all situated in parts where these limestones are in near contact with the granite; and he considers, that they have all, most probably, been filled by the sublimation of mineral matter into cavities of the limestones, at, or soon after, the time of the elevation of the granite of this part of the Pyrenees. The period of this elevation was posterior to the deposit of the chalk formation, and anterior to that of the tertiary strata. These limestones have all become crystaline where they are in contact with the granite; and the iron is in some places mixed with copper pyrites, and argentiferous galena."

With regard to the general direction of these veins, Professor Buckland observes—

"A further result attending the disturbances of the surface of the earth has been, to produce rents or fissures in the rocks which have been subjected to these violent movements, and to convert them into receptacles of metallic ores, accessible by the labours of man. The greater part of metalliferous veins originate in enormous cracks and crevices, penetrating irregularly and obliquely downwards to an unknown depth, and resembling the rents and chasms which are produced by modern earthquakes. The general disposition of mineral veins within these narrow fissures will be best understood by reference to our first section. The narrow lines that pass obliquely from the lower to the upper portion of this section, represent the manner in which rocks of various ages are intersected by fissures which have become the receptacles of rich treasures of metallic ore. These fissures are, more or less, filled with various forms of metalliferous and earthy minerals, deposited in succession, and often in corresponding layers on each side of the vein."

In another part of the same work, he adds—

"This section, reduced from Thomas's Survey of the Mining District of Cornwall, exhibits the manner in which the granite and slate near Redruth are intersected by metalliferous veins, terminated abruptly at the surface, and descending to an unknown depth; these veins are usually most produc-

tive near the junction of the granite with the slate, and where one vein intersects another. The mean direction of the greatest number of them is nearly from E.N.E. to W.S.W. They are intersected, nearly at right angles, by other and less numerous veins, called cross courses, the contents of which usually differ from those of the E. and W. veins, and are seldom metalliferous.

"The granite, and Killas and other rocks, which intersected them, *e. g.* dykes and intruded masses of more recent granite, and of various kinds of porphyritic rocks called Elvans, are considered to have occupied their present relative positions before the origin of the fissures which form the metalliferous veins that intersect them all."*

Mr. Lyell is rather concise on this branch of geological research, but quite conclusive. He states that—

"Granite, sienite, and those porphyries which have a granitiform structure, in short all plutonic rocks, are frequently observed to contain metals, at or near their junction with stratified formations. On the other hand, the veins which traverse stratified rocks are, as a general law, more metalliferous near such junctions than in any other positions. Hence it has been inferred, that these metals may have been spread in a gaseous form through the fused mass, and that the contact of another rock, in a different state of temperature, or sometimes the existence of rents in other rocks in the vicinity, may have caused the sublimation of the material."

And at another place he says—

"Near Champoleon, a granite composed of quartz, black mica, and rose-coloured felspar, is observed partly to overlie the secondary rocks, producing an alteration which extends for about thirty feet downwards, diminishing in the beds which lie farthest from the granite. In the altered mass the argillaceous beds are hardened, the limestone is saccharoid, the gritz quartzose, and in the midst of them is a thin layer of imperfect granite. It is also an important circumstance, that near the point of contact, both the granite and the secondary rocks become metalliferous, and contain nests and small veins of blende, galena, iron and copper pyrites.†

Professor Phillips, with respect to this point, observes—

"Mineral veins abound in particular parts of the carboniferous rocks, chiefly in the limestone districts, and near to some considerable dislocations or axis of distinct elevation.

"Scarcely a mine in the British Islands is worked in the old red sandstone, or true coal measures; very few are established in the districts which, like a large part of the Irish limestone, are removed from axes and centres of disturbance.

"But the dislocated mountain limestone of Cumberland, Durham, Yorkshire, Derbyshire, Flintshire, Mendip, and South Wales, and partially that of Belgium and Silesia, is characterized by prevalence of veins of lead, copper, calamine, and oxide of iron. There is seldom found in these districts the same great variety of metallic ores as in the older primary tracts; the vein stuff, the matrix of the ore, differs according to locality; fluor-spar abounds in the mines of Alaston Moor, &c., carbonate of Barytes in Derby-

* Bridgewater Treatise, vol. i. pp. 548, 549, and vol. ii. pp. 107, 108.
† Elements, vol. ii. pp. 342, 343, 363.

shire. It is seldom that the same mining districts, almost never the same veins, yield copper and lead in abundance.

"Most of the veins of fissure are accompanied by dislocation (faults), sometimes to the extent of several hundred feet, sometimes only a few inches. They pass through the stratiform basalt of Northumberland and Yorkshire, and *yield ore in it abundantly*. . . . . . Pipe veins are of less frequent occurrence and inferior interest.

"The same phenomena of some veins crossing and cutting others occur in this district as in the older strata, and the same tendencies to peculiar directions are recognised; the bearing veins running generally East-North-East, or nearly so, and the cross courses North-by-West, in the North of England aud Flintshire."

At another part of his work he declares

"It to be a general truth, that metallic veins abound in proportion to the proximity of the situation to axes of dislocation, and eruptions of pyrogenous rocks."*

The evidences on this important branch of geological research will be summed up by a quotation from Prof. Playfair's Illustrations of the Huttonian Theory, the perspicuity of which is only surpassed by the correctness of its style. Circumstances, however, render it necessary to abridge these passages, which I regret, and, therefore, recommend the work itself to the reader:—

"The unstratified minerals exist," observes the Professor, "either in veins intersecting the stratified, or in masses surrounded by them. Veins are of various kinds, and may, in general, be defined as separations in the continuity of a rock, of a determinate width, but extending indefinitely in length and depth, and filled with mineral substances different from the rock itself. The mineral veins, strictly so called, are those filled with crystalized substances, and containing the metallic ores. That these veins are of a formation subsequent to the hardening and consolidation of the strata which they traverse, is too obvious to require any proof; and it is no less clear from the crystalized and sparry structure of the substances contained in them, that these substances must have concreted from a fluid state. Now, that this fluidity was simple, like that of fusion by heat, and not compound, like that of solution in a menstruum, is inferred from many phenomena. It is inferred from the acknowledged insolubility of the substances that fill the veins in any one menstruum whatsoever; from the total disappearance of the solvent, if there was any; from the complete filling up of the veins by the substances which that solvent had deposited; from the entire absence of all the appearances of horizontal or gradual deposition; and, lastly, from the existence of close cavities, lined with crystals, and admitting no egress to anything but heat. . . . . . The metals contained in the veins which we are now treating of, appear very commonly in the form of an ore mineralized by sulphur. Their union with this latter substance can be produced, as we know, by heat, but hardly by the way of solution in a menstruum, and certainly not at all if that menstruum is nothing else than water. The metals, therefore, when mineralized by sulphur, give no conntenance to the hypothesis of aqueous solution; and still less do they give any when they are found native, as it is called; that is, malleable, pure, and uncombined

* Treatise, pp. 111, 112, 91.

with any other substance. . . . . . Gold, however, the most perfect of the metals, is found native most frequently; the others more rarely in proportion nearly to the facility of their combination with sulphur. Of all such specimens it may be safely affirmed, that if they have ever been fluid, or even soft, they must have been so by the action of heat; for, to suppose that a metal has been precipitated pure and uncombined from any menstruum is to trespass against all analogy, and to maintain a physical impossibility. But it is certain that many of the native metals have once been in a state of softness, because they bear on them impressions which they could not have received but when they were soft. Thus, gold is often impressed by quartz and other stones, which still adhere to it, or are involved in it. Specimens of quartz, containing gold and silver shooting through them, with the most beautiful and varied ramifications, are everywhere to be met with in the cabinets of the curious; and contain in their structure the clearest proof that the metal and the quartz have both been soft, and have crystalized together. Native copper is very abundant, and some specimens of it have been found crystalized. Here the crystalization of the metal is a proof that it has passed from a fluid to a solid state; and its purity is a proof that it did not make that transition by being precipitated from a menstruum. Again, pieces of native manganese have been found possessing so exactly the character peculiar to that metal, when reduced in our furnaces, that it is impossible to consider them as deriving their figure and solidity from any cause but fusion. . . . . . All these appearances conspire to prove, that the materials which fill the mineral veins were melted by heat, and forcibly injected, in that state, into the clefts and fissures of the strata. . . . . . In the view now given of metallic veins they have been considered as traversing only the stratified parts of the globe. They do, however, occasionally intersect the unstratified parts, particularly the granite, the same vein often continuing its course across rocks of both kinds, without suffering any material change. . . . . . It is material to remark that, though metallic veins are found indiscriminately in all the different kinds of rock, whether stratified or otherwise, they are most abundant in the class of primary schisti. . . . . . This preference which the metals appear to give to the primary strata, is very consistent with Dr. Hutton's theory, which represents the rocks of that order as being most changed from their original position, and those on which the disturbing forces of the subterraneous regions have acted most frequently, and with greatest energy. The primary strata are the lowest also, and have the most direct communication with those regions from which the mineral veins derive all their riches."*

A more perfect conception of the *direction* in which these veins intersect each other, and run through the rocks composing the earth's outer crust, will be acquired by reference to any of those geological maps which have been already enumerated, and which embrace extended areas of primary formation; for by them it will be seen, that the metalliferous veins generally cut one another at right angles; *while they penetrate each successive formation without causing the slightest dislocation, or derangement of the relative positions of contiguous rocks.*

* Illustrations of the Huttonian Theory, pp. 72—81.

Having perused these evidences, which are meant to show the *localities*, and the usual *direction* of metallic veins, I shall next submit some information as to their supposed *origin*, or the causes which produced them.

"Several hypotheses," according to Professor Buckland, "have been proposed to explain the manner in which these chasms in solid rocks have become filled with metallic ores, and with earthy minerals, often of a different nature from the rocks containing them. Werner supposed that these veins were supplied by matter descending into them from above, in a state of aqueous solution; whilst Hutton and his followers imagined that their contents were injected from below in a state of igneous fusion. A third hypothesis has been recently proposed, which refers the filling of veins to a process of *sublimation* from subjacent masses of intensely heated mineral matter, into apertures and fissures of the superincumbent rocks. A fourth hypothesis considers veins to have been slowly filled by *segregation*, or infiltration, sometimes into contemporaneous cracks and cavities, formed during the contraction and consolidation of the originally soft substances of the rocks themselves; and more frequently into fissures produced by the fracture and dislocation of the solid strata. Segregation of this kind may have taken place from electro-chemical agency, continued during long periods of time."*

In another part of his work, Dr. Buckland gives some particulars respecting Mr. Fox's views and experiments, which are extracted with much pleasure, in consequence of the surmise, that *they contain "the rudiments of the true theory of metallic veins."*

"The following observations," says he, "by Mr. R. W. Fox, in a recent communication to the Geological Society of London, April, 1836, appear to contain the rudiments of a theory, which when maturely developed, promises to offer a solution of this difficult and complex question:—

"'If it be admitted that fissures may have been produced by changes in the temperature of the earth, there can be little difficulty in also admitting that electricity may have powerfully influenced the existing arrangements of the contents of mineral veins; how are we otherwise to account for the relative positions of veins of different kinds with respect to each other, and likewise for their contents in reference to the rocks which they traverse, and many other phenomena observable in them of a very decided and definite character? Copper, tin, iron, and zinc, in combination with the sulphuric and muriatic acids, being very soluble in water, are in this state capable of conducting voltaic electricity; so, if by means of infiltration, or any other process, we suppose the water to have been impregnated with any of these metallic salts, the rocks containing different salts would undoubtedly become in different or opposite electrical conditions; and hence, if there were no other cause, electrical currents would be generated, and be readily transmitted through the fissures containing water, with salts in solution; and decompositions of the salts, and a transference of their elements, in some cases to great distances, would be the natural result. But, on the known principles of electro-magnetism, it is evident that such currents would be more or less influenced in their direction and intensity by

* Bridgewater Treatise, vol. i. pp. 550—552.

the magnetism of the earth. They cannot, for instance, pass from N. to S., or from S. to N. so easily as from E. to W., but more so than from W. to E. The terrestrial magnetism would, therefore, tend, in a greater or less degree, to direct the voltaic currents through those fissures which might approximate to an east and west bearing, and, in separating, the saline constituents would deposit the metal within or near the electro-magnetic rocks, and the acid would be determined toward the electro-positive rock, and probably enter into new combinations; or the sulphuric acid might, by means of the same agency, be resolved into its elements; in which case the sulphur would take the direction of the metal, and the oxygen of the acid, and in this way the metallic sulphurets may have derived their origin; for, if I mistake not, the metallic sulphates, supposing them to have been the prevailing salts, as at present, would be fully adequate to supply all the sulphur required by the same metals to form sulphurets; indeed, more than sufficient, if we deduct the oxides of tin, and other metalliferous oxides found in our mines. The continued circulation of the waters would, in time, bring most of the soluble salts under the influence of these currents, till the metals were, in great measure, separated from their solvents, and deposited in the east and west veins, and near the rocks to which they were determined by the electric currents.'"

And again—

"Mr. Fox has found by experiment that when a solution of muriate of tin is in the voltaic current, a portion of the metal is determined towards the negative pole, whilst another portion in the state of an oxide passes to the positive pole. This fact appears to him to afford a striking illustration of the manner in which tin and copper have been separated from each other in the same vein, or in contiguous veins, while these metals also very commonly occur together in the same veins."*

Following up these conceptions and discoveries of Mr. Fox, the following is subjoined from the *Literary Gazette.*

The editors of that periodical say—

"Mr. Fox has for some time—and hitherto very successfully—turned his attention to the formation of mineral bodies or veins; and to the principle of electro-magnetism, as applied to these formations. It had been observed by him, and by others acquainted with the peculiar structure of the Cornish metalliferous deposits, that the same lode would sometimes contain copper pyrites; and within a short distance, and merely separated by the common argillaceous substances, sulphate of copper, or some other modification of the same material. Whenever this occurred, the lode was generally found to be saturated with water, containing various salts; a circumstance that seems to influence in some degree the change in the mineral deposit. Mr. Fox, applying the exercise of his strong and highly-cultivated mind to these phenomena, immediately conceived the notion that electro-magnetism was the prime agent in the production of this extraordinary change. To prove this he procured an earthen pan, which he divided into two compartments, by inserting in the centre a barrier of clay, saturated with dilute sulphuric acid, and jammed down closely. In the one compartment he placed water, charged with the sulphate of copper; and in the other dilute sulphuric

* Bridgewater Treatise, vol. ii. pp. 108—110.

acid. In the sulphuric acid he placed plates of zinc, connected with a rod and wire with a piece of copper pyrites, suspended in the water contained in the other compartment. In a short time electro-magnetism commenced. The sulphur passed from the water, through the barrier of clay to the zinc, and there not being sufficient sulphur in that water to form, by this union, sulphate of zinc, the copper pyrites was deprived of a portion of its sulphur, and changed to common grey copper! Mr. Fox thinks he shall be enabled to complete this experiment without the dilute sulphuric acid, and merely by water."*

M. de la Beche, when treating on this matter, says—

"To enter fully into the subject *of the occurrence of metals in rocks* would require a volume; the following notice is, therefore, solely intended to call the attention to a few circumstances which may be generally interesting:—

"Metals occur in rocks either disseminated; in bunches; in a network of strings or small veins; in beds; or in veins filling fissures, which traverse beds or masses of rock. . . . . .

"The most common occurrence of metals is, however, in veins, or, as they are termed in Cornwall, *lodes*. These are in part filled up, but in various proportions, with metallic substances, and have the general appearance of fissures. They dip at various angles, not unfrequently approaching a vertical position. It was at one time much disputed whether these fissures had been filled from above or beneath; but from facts that have been noticed within a few years, more particularly by Mr. Taylor and Mr. Carne, there is much difficulty in considering that either hypothesis is generally correct. It now appears that the mineral character of a metalliferous vein greatly depends upon the rock which it traverses; that is, when a vein traverses two rocks, as, for instance, granite and slate, the contents of the vein are not, generally, the same in the two rocks, but will be different in the one and the other. . . . . .

"This fact of the alteration of metallic veins in their passage from one kind of rock to another, or in the same rock, should that become changed, would lead us to consider, with Mr. Fox, that their formation has been, in a great measure, due to the silent though powerful influence of electricity. This enquiry may yet be considered in its infancy; but the experiments of Mr. Fox on the electro-magnetic properties of the metalliferous veins of Cornwall will be read with great interest.

"Mr. Fox considers that the relative power of conducting galvanic electricity is in the following order in some of the metalliferous minerals. *Conductors*—Copper, nickel, purple copper, yellow sulphuret of copper, vitreous copper, sulphuret of iron, arsenical pyrites, sulphuret of lead, arsenical cobalt, crystalized black oxide of manganese, tennantite, Fahlerz. *Very imperfect conductors*—Sulphuret of molybdenum, sulphuret of tin, or rather bell-metal ore. *Non-conductors*—Sulphuret of silver, sulphuret of mercury, sulphuret of antimony, sulphuret of bismuth, cupriferous bismuth, realgar, sulphuret of manganese, sulphuret of zinc, and mineral combinations of metals, with oxygen and with acids." (Phil. Trans., 1830, p. 399.)†

Professor Phillips thus expresses himself on this new and interesting branch of geological research—

"One might venture to say there is a peculiar electric attraction between

* Literary Gazette of 3rd May, 1836, p. 296.

† Manual, p. 521—523.

sulphuret of lead and limestone rock; and this idea, followed so far, leads to the doctrine of the metallic contents being secreted from the bordering rocks. The materials of the veins seem, indeed, in many instances, to have been transferred by electric currents through solid substances, but they are really diffused *from* the veins into the cavities of the neighbouring rocks, not collected from these *into* the vein fissures."

And at another place he says—

"The first notions *on the direction of convulsive movements* were formed by miners, who observed, as a fact of great practical importance to their art, that the mineral veins which were most generally and uniformly productive ranged *east* and *west*, or nearly; and that these *right running* veins were divided by *cross-courses*, passing *north* and *south*, or nearly.* Not that there are no other directions of veins and cross-courses, but amidst many directions these prevail. Cornwall, Wales, Cumberland, the Penine limestone region, Brittany, the Hartz, the Hungarian mines, and even Mexico, appear to confirm this law, suggested by practical men. It is very difficult, or rather impossible, to explain it; but we may remark, that in many cases, the direction of mineral veins follows that of the natural joints and fissures produced by consolidation of the rocks; and that it is very conceivable that electrical currents, or other polarizing agents, might communicate to such fissures one or more definite directions. In fact, it is proved that, in Yorkshire, Derbyshire, and other large tracts, these fissures have definite directions, mostly rectangular to one another. . . . . .

And again—

"The *origin of mineral veins* has long been, and will for some time continue, a disputable question in geology; but considerable progress has been made in it since the days of Werner and Playfair. *The origin of the fissures*, in which a great proportion of mineral veins occur, is certainly proved to be either by molecular attraction, causing contraction of the mass of rocks, and thus generating joints or divisional planes, or by the tension of elevatory forces, as explained in the last section.

" . . . . . *Repletion of mineral veins.*—The opinion of the Cornish miners and geologists generally appears to be, that most all of these veins are to be regarded as contemporaneous with the rocks which enclose them.

" . . . . . Whatever force may be thought due to the facts and the opinions brought forward on the subject of veins in Cornwall, it is perfectly certain, that in distinctly stratified countries, the mineral matter has been introduced into open fissures long after the deposition and consolidation of the strata. *The proof is unanswerable.* Joints and fissures filled with metallic and sparry matters (mineral veins), pass through rocks which are not contemporaneous but successively deposited, and *divide corals, fishes, &c.* It is evident that this must close the discussion as far as regards these rocks. But though it cannot be reasonably doubted, as a general truth, that the vein-stuff has been transferred into open fissures of the rocks, it is not so easy to determine how this was effected. Have the materials been injected from below as lavas into the fissures of a mountain (Hutton), or sublimed from a hot region to a cold fissure (Buckland), or segregated by

* This is precisely the direction which these "*cross courses*" should take on a sphere revolving, for the first time, around its axis, from west to east, and expanding most towards the equatorial regions.—AUTHOR.

some peculiar influence from the neighbouring rocks (Sedgwick), or poured into them in aqueous solution (Werner), or transferred by electrical currents (Fox), as in some instances we have good reason to believe?

"In the present state of our knowledge neither of these results can be admitted exclusively, yet, perhaps, none ought to be absolutely rejected as a cause of the repletion of metalliferous fissures."*

* Treatise, pp. 262, 263, 270—273.

SECTION V.

GEOLOGICAL PHENOMENA RESULTING FROM THE EARTH'S PROTOROTATION.

CHAPTER XXIV.

Recapitulation of points established in the preceding Chapter. Conclusions to be drawn from the oblique direction of metallic veins: various means by which their contents may have been lodged in them. Thermo-electricity that which most probably was employed. Proofs in favour of this assumption, and the manifold evidences of beneficent design in the formation, and in the location of metallic veins. Geological testimonies of the existence of amorphous rocks, capable of having occasioned the electrical currents, and other phenomena from which these metalliferous veins originate. Granitic Rocks: their genera, position, and their relation to associated and superincumbent formations. Enquiry into their supposed origin with respect to the internal structure of the Earth, and the assistance which the Dynamical Theory affords, by simplifying this difficult question.

The mind having been prepared by the extracts and opinions which have been so abundantly given in the preceding chapter, let us now endeavour to come to some conclusion which may assist in eventually leading to the truth. We are already furnished with a considerable amount of data to enable us to proceed satisfactorily with the solution of this difficult problem; I shall take the liberty of recapitulating them. Firstly, then, the *direction* of the veins is ascertained; secondly, we know their *contents*, and the contents of the cross courses; thirdly, we are aware of their *relative geological positions*, and that they do not cause faults or dislocations amongst the formations through which they pass; fourthly, we are convinced that a *force* of some kind sufficient to have caused their formation, and especially their *direction* must have been employed; and, lastly, we know the nature and direction of *all forces*. Therefore, *that* which was employed by the Creator, as the secondary cause, in forming the metallic veins, may, perhaps, be discovered by the application of the differential method of reasoning.

From the perpendicular direction in which *mineral* veins proceed towards the surface, it has been shown, in treating of them, that they owe their origin to a combination of the centrifugal impetus occasioned by the rotation of the earth around its axis, and to the

heat which was engendered thereby, especially at the axes of elevation; and if this be contrasted with the *oblique* direction in which *metallic* veins proceed to the same point, we shall at once be convinced, *that these latter cannot have emanated from the same cause which produced the others:* unless, indeed, it should be imagined, that unlike any other force, it could have simultaneously given birth to two sets of veins proceeding in different directions. We may, therefore, discard the centrifugal impetus as not being the *immediate cause* of the direction of the metalliferous veins; and in this manner dispose of one of the known forces.

Neither could the *oblique direction* of these veins result from a composition of forces, between that engendered by centrifugal impetus towards the circumference, and a tangential force at right angles thereto: because, though this might account for some of these diagonal lines, it completely fails when applied to those which *cut the others at right angles;* and, therefore, this also may be dismissed as not having been the immediate cause of the fissures in question.

Infiltration from without may be disposed of in the same manner. For, although it is probable it may have been the means of filling the external fissures—when once they were made—with mineral and metallic solutions, *it could not have caused the fissures themselves;* both on account of its inadequacy as well as the oblique direction in which these proceed. A liquid, if it could by any possibility have so penetrated as to have caused fissures in solid rock, would, by the laws governing its motion, have done so in lines perpendicular to the earth's surface. We may, therefore, eliminate this cause of origin also from the catalogue. Consequently, by the disposal of those forces, we are shut up to select the only remaining power at all capable of producing these metallic veins, namely, *some one of the various modifications of electrical agency;* a conclusion, which not only agrees with Mr. Fox's conceptions and experiments; but likewise harmonises with the results of geological research amongst the formations where these veins abound. The particular kind of electricity which seems best to accord with what has been observed, is that called *Thermo-electricity;** and, in consequence, after relating some particulars regarding its discovery and its manner of acting, I shall endeavour to apply it to the case in question and show its sufficiency.

"It has already been observed," says the author of the *Connexion of the Sciences,* "that three bodies are requisite to form a galvanic circuit, one of which must be a fluid. But in 1822, Prof. Seebeck, of Berlin, discovered that electric currents may be produced by the partial application of heat to a circuit formed of two solid conductors. For example, when a semi-circle of bismuth, joined to a semi-circle of antimony, so as to form a ring, is heated at one of the junctions by a lamp, a current of electricity flows through the circuit from the antimony to the bismuth, and such

* Theorems 59 to 66.

thermo-electric currents produce all the electro-magnetic effects. . . . . . M. Nobili observed that in all metals, except zinc, iron, and antimony, the electricity flows from the hot part towards that which is cold. That philosopher attributes terrestrial magnetism to a difference in the action of heat on the various substances of which the crust of the earth is composed; and in confirmation of his views he has produced electrical currents by the contact of two pieces of moist clay, one of which was hotter than the other.

"M. Bequerel constructed a thermo-electric battery of one kind of metal, by which he has determined the relation between the heat employed, and the intensity of the resulting electricity. He found that in most metals the intensity of the current increases with the heat to a certain limit, but that this law extends much farther in metals which are difficult to fuse, and which do not rust. The experiments of Professor Cumming show, that the mutual action of a magnet and a thermo-electric current is subject to the same laws as those of magnets and galvanic currents, consequently all the phenomena of repulsions, attraction, and rotation, may be exhibited by a thermo-electric current."

And at another place this author observes—

"Dr. Faraday has proved by recent experiments on bodies, both in solution and fusion, that electrical affinity is merely a result of the electrical state of the particles of matter."*

"If the theory of internal heat," says M. de la Beche, with his usual circumspection, "be well founded, it will be evident that the two ends of a metallic vein will be differently heated, and therefore we should have a thermo-electrical apparatus on a large scale, producing effects which, though slow, might be very considerable. How far such really exists in nature remains questionable, but it may be observed that the experiments of Mr. W. Fox show the possibility of their occurrence; and should further researches in this highly interesting subject so divide it, that some of its present apparent complexity may disappear, a great advance will be made in this now obscure branch of geological enquiry."†

Professor Playfair, with his characteristic acumen, refutes the Neptunian while he vindicates the Plutonic hypothesis, as far as the formation of metals in veins is concerned, in the following conclusive passage of his Illustrations:—

"The state in which gold and silver are often found pervading masses of quartz, and shooting across them in every direction," he remarks, "furnishes a strong argument for the igneous origin both of the metal and the stone. From such specimens it is evident, that the quartz and the metal crystalized, or passed from a fluid to a solid state, at the same time: and it is hardly less clear, that this fluidity did not proceed from solution in any menstruum: for the menstruum, whether water or the *chaotic fluid*, to enable it to dissolve the quartz, must have had an alkaline impregnation; and to enable it to dissolve the metal, it must have had, at the same time, an acid impregnation. But these two opposite qualities could not reside in the same subject; the acid and the alkali would unite together, and, if equally powerful, form a neutral salt, like sea salt, incapable of acting either on the metallic or the siliceous body. If the acid was most powerful,

* Mrs. Somerville on the Connexion of the Sciences, pp. 345, 346, 123.

† Manual, p. 524.

the compound salt might act on the metal, but not at all upon the quartz; and if the alkali was most powerful, the compound might act on the quartz, but not at all on the metal. In no case, therefore, could it act on both at the same time. Fire or heat, if sufficiently intense, is not subject to this difficulty, as it could exercise its force with equal effect on both bodies."*

And, in further confirmation of this particular point, reference is requested to the conclusive evidence given at page 358 of Mr. Lyell's Elements, which, in consequence of having been so recently quoted, is not repeated.†

What has been adduced will sufficiently prove, that heat, when applied to distinct mineral substances—unequal conductors—puts those associated materials into a condition proper for eliciting currents of thermo-electricity; while, what was previously established, leaves as little doubt on the mind, that during the first rotation of the earth around its axis, there was sufficient heat evolved to act as a *primum momentum* in this case, to set those dormant currents into active operation. And if there be added the corroborative consideration that the strata, at the period when these operations are supposed to have taken place, were impregnated with metallic depositions in combination with other elements, agreeing precisely with those discovered in metallic veins, we shall be convinced, that according to the wise and beneficent ordinations of the Creator, all the requisites were amply prepared for the event; so that the thermo-electrical currents, when put into exercise, had wherewithal to operate upon, and to produce, with due separation, either by sublimation, or rapid segregation, those abundant stores of metallic ores, destined to be transmuted thereafter for the use of man.

If a view be taken of any sectional geological map, and, at the same time, it be remembered, that "the granite and killas—the intruded masses of more recent granite—and the various kinds of porphyritic rocks, called elvans, are considered to have occupied their present relative positions before the origin of the fissures, forming the metalliferous veins which intersect them all,"‡ the final conclusion must be come to, that they were, in fact, formed *after* these mineral masses assumed their present positions; because *the fissures or veins pass indiscriminately, and almost in straight lines, through the whole.*§ Consequently, they originated when the heat and electrical influences, occasioned by the friction arising from the movement amongst these masses, were at their maximum; that is *towards the conclusion of the first day's rotation of the earth around its axis.* That this *was the period of their formation* must appear obvious when it is considered, in the first instance, that they could not have existed *before*, because the general movement which ensued amongst

* Illustrations of the Huttonian Theory, vol. i. pp. 249, 250.

† Elements of Geology, vol. ii. p. 343.

‡ Professor Buckland's Bridgewater Treatise, vol. ii. p. 108.

§ In confirmation of this, see especially a passage in Phillips's Treatise, p. 272, on the authority of *Rep. Brit. Association*, Edinburgh meeting.

the rocks of the earth's crust when its rotation took place, would have completely deranged their lines of junction, had they been formed when these rocks lay, as yet, in a horizontal position; and, in the next, we know of no event posterior thereto sufficient to have produced them; while, *in what then occurred, there were causes put in operation, according to the thermo-electric theory, sufficient to have done so.*

The argument opposed to the supposition—that these fissures originated in a shrinking of the rocks—amounts almost to demonstration. For, although fissures from contraction, when a mineral which has been heated begins to cool, is perfectly supposable in the case of one homogeneous mass, it is quite inadmissible when applied to the case in question, as the fissures pass in straight lines indiscriminately through granite, trap, porphyry, greenstone, gneiss, grauwacke, limestone, and all other descriptions of clay, or aluminous formations; it being scarcely possible to conceive that the same degree of heat could have produced so equal an effect on substances differing so materially in their nature and relation for that subtile element, and, more especially, those of aluminous composition, which, unlike the other associated masses, so far from *expanding* on the application of heat, are found to *contract.* But none of these difficulties exist, when the result is attributed to the agency of thermo-electricity; all the requisites for its evolution were present; and when emanating from such centres of heat as the nucleii of mountain chains or axes of disturbance, it must have been sufficient to have overcome every barrier; whilst the electrical influence, in proceeding "from the heated parts towards those which were cold," would pursue the very direction in which these metallic veins are found to run, *provided they emanated when the mountains were at their highest elevation;* which agreeing, likewise, with the period of the maximum of heat, fulfils all the conditions of the problem; *and fixes the era of their formation with unlooked-for precision.*

Allusion may here be made to the interesting observations of Professor Buckland, and others mentioned by him, with regard to the evidences afforded *of wise and beneficent design for the well being of man,* in the manner in which both the precious and the useful metals have been deposited in lodes or veins.* What has been said is true, and evinces the constant presence and agency of an ever watchful Providence, while it demonstrates, in the clearest manner, the wisdom, prescience, and goodness of God. Another instance of consideration for man's welfare, is manifested by the *direction* which these metallic veins were made to take amongst the mineral masses where they exist.

Had they, like the *mineral* veins, been under the influence of the centrifugal impetus—emanating as they did from the nucleii of mountain chains, *after* these reached their highest elevations—they

* Bridgewater Treatise.

would, in most cases, have had not only a longer course to run in order to reach the surface, but would have made their appearance upon the scarped, arid, and uninhabitable summits and shoulders of these primary masses, whose bare and rugged surfaces would have rendered them almost inaccessible, and scarcely capable of having been wrought. They would also have been much more concentrated; and, consequently, less equally divided amongst the world's inhabitants. Besides all these inconveniences, it is more than probable, that had they merely obeyed the laws of centrifugal force, and had commenced their course, as they evidently have done, *after* the formation of all the mineral veins and dykes, they would not have had impetus sufficient to have perforated these, but would have been embarrassed, "nipped," if not entirely interrupted in their way to the surface. All these inconveniences and impediments, however, have not only been avoided and overcome by infinite wisdom, but they have been transformed into positive benefits, by the metalliferous veins being caused to emanate from the irresistible power of thermo-electricity, and to shoot forth, not before, but *after*, the elevation of the mountains in which they abound. Born of this subtile influence, they were not only enabled to pass unresistingly through every obstacle, *but likewise to follow the most direct route to the surface;* while by their eruption, after the earth had assumed its actual form, that *direction* was so disposed as to occasion their spreading over an extent of country, which—though not the most fertile—is at least incomparably better than the rugged peaks amongst which they would, otherwise, have abounded. And, even the circumstance of these metallic treasures being conferred on countries not the most fertile in vegetable productions, in consequence of their geological position and agricultural character, evinces a true parental foresight and benevolence of design, together with a just impartiality towards the world's inhabitants, who all, alike, are the children of the same Creator.

This idea is so admirably brought out in the passage alluded to, that I feel myself constrained to insert it:—

"Whatever may have been the means," observes Dr. Buckland, "whereby mineral veins were charged with their precious contents; whether segregation or sublimation was the *exclusive* method by which the metals were accumulated; or whether each of the supposed causes may have operated simultaneously or consecutively in their production; the existence of these veins remains a fact of the highest importance to the human race; and although the disturbances, and other processes in which they originated, may have taken place at periods long antecedent to the creation of our species, we may reasonably infer that a provision for the comfort and convenience of the last and most perfect creatures he was about to place upon its surface, was in the providential contemplation of the Creator, in his primary disposal of the physical forces, which have caused some of the earliest and most violent perturbations of the globe."*

* Bridgewater Treatise, vol. i. pp. 554, 555.

All that is now wanting to conclude these detailed investigations into the diversified phenomena, attendant on the elevation of mountain chains, accompanied by the forcible injection, by means of the centrifugal impetus, of enormous masses of unstratified rock, is, to enquire, *whether geologists recognise a mineral of such a character and general prevalence, as may warrant our relying, with implicit confidence, on the inferences which have been drawn from its supposed existence?* To do this, I shall refer, in succession, to the *twentieth*, *twenty-third*, and *twenty-fifth* Theorems, in all of which that point is more or less elicited; while the attention is directed, for the present, more exclusively to the last of these, in which it is stated, "*That granite is found to be essentially the same wherever it hitherto has been examined. That it is in the deeper regions of the globe, where granite has its origin, that that of trap must also be looked for. That whatever difference may exist between these rocks, whether in their relation to the strata or their mineralogical character, they are remarkably analogous in almost every important general circumstance.*

"*And that there is good reason even for considering that granite, porphyry, and trap have had a common origin.*"

The principal evidences on which that opinion is founded are the following:—

"The term granite," observes Professor Playfair, "is used by Dr. Hutton to signify an aggregate stone, in which quartz, felspar, and mica are found distinct from one another, and not dispersed in layers. The addition of hornblend, schorl, or garnet, to the three ingredients just mentioned, is not understood to alter the *genus* of the stone, but only to constitute a specific difference, which it is the business of lithology to mark by some appropriate character, annexed to the generic name of granite. . . . . .

"One ingredient which is essential to granite, namely, quartz, is not contained in whinstone; and this circumstance serves to distinguish these *genera* from one another, though in other respects, they seem to be united by a chain of insensiblé gradations, from the most homogeneous basalts, to granite the most highly crystaline."*

"Assuming," says Dr. Buckland, in a passage already quoted, "that fire and water have been the two great agents employed in reducing the surface of the globe to its actual condition, we see, in repeated operations of these agents, causes adequate to the production of these irregular elevations and depressions of the fundamental rocks of the granitic series, which are delineated in the lower region of our section, as forming the basis of the entire superstructure of stratified rocks."

At another part of his work, when tracing the origin of volcanic rocks, basalt and trap dykes, he adds—

"As the mineral characters of these dykes present insensible gradations, from a state of compact lava, through infinite varieties of greenstone, serpentine, and porphyry, to granite, we refer them all to a common igneous origin."†

* Illustrations of the Huttonian Theory, pp. 95, 96.
† Bridgewater Treatise, vol. i. p. 48, and vol. ii. p. 3.

"Such are the rocks," says M. de la Beche, "namely, *granite*, *porphyry*, *diallage*, *serpentine*, *basalt*, *greenstone*, and other rocks, usually termed *trappean; claystone*, *clinkstone*, *&c.*, commonly called unstratified. It will have been seen that they so pass into one another, that distinctions are not easily established between them. Mineralogical granite passes through various stages, and graduates into the compounds named greenstone, and others of the trappean class." . . . . .

Again—

"The trappean rocks, though there is much difficulty in separating them from the granitic, may for convenience be considered separately from them."

Further on he says—

"The above is sufficient to show, that trap, under certain conditions, may pass into serpentine. . . . . . The serpentine and diallage rocks of Liguria are particularly instructive, as they appear under a variety of forms, and seem to be connected with the disturbance of the strata in that country."

And in conclusion from this geologist—

"If we regard these various igneous products as a matter which has successively, and during the lapse of all that time comprehended between the earliest formation of the stratified rocks and the present day, been ejected from the interior of the earth, we shall be struck with certain differences of these rocks on the great scale, which has led to their practical arrangement under the heads of granitic, trappean, serpentinous, and volcanic products as above noticed. . . . . . As yet we are unacquainted with the conditions necessary for the production of these different compounds. . . . . . Possibly the quantity and proportion of the elementary substances might not vary as much as we might, from the general mineral character alone, be led to expect, but at first sight we may imagine that silica predominated more in the granitic rocks than in the others, while magnesia abounded in those parts of the earth which vomited forth the serpentinous deposits."*

"The plutonic rocks," observes Mr. Lyell, "may be treated of next in order, as they are most nearly allied to the volcanic class already considered. . . . . . By some writers, all the rocks now under consideration have been comprehended under the name of granite, which is then understood to embrace a large family of crystaline and compound rocks, usually found underlying all other formations; whereas we have seen that trap very commonly overlies strata of different ages. . . . . . Although it is the general peculiarity of granite to assume no definite shape, it is, nevertheless, occasionally subdivided by fissures, so as to assume a cuboidal and even a columnar structure. . . . . .

"Felspar, quartz, and mica are usually considered as the minerals essential to granite, the felspar being most abundant in quantity, and the proportion of quartz exceeding that of mica. . . . . *Porphyritic granite.*—This name has been sometimes given to that variety in which large crystals of felspar, sometimes more than an inch in length, are scattered through an ordinary base of granite. . . . . . *Sienite.*—When hornblend is the substitute for mica, which is very commonly the case, the rock becomes sienite;

* Manual of Geology, pp. 486—489, 493, 498, 500.

so called from the celebrated ancient quarries of Syene, in Egypt. It has all the appearance of ordinary granite, except when mineralogically examined in hand specimens, and is fully entitled to rank as a geological member of the same plutonic family as granite. . . . . . *Sienitic-granite.*—The quadruple compound of quarts, felspar, mica, and hornblend, may be so termed. This rock occurs in Scotland and in Guernsey. *Talcose granite,* or protogine of the French, is a mixture of felspar, quartz, and talc. It abounds in the Alps, and in some parts of Cornwall. . . . . . *Schorl rock and schorly granite.*—The former of these is an aggregate of schorl, or tourmalin, and quartz. When felspar and mica are also present, it may be called schorly granite. This kind of granite is comparatively rare. *Eurite.*—A rock in which all the ingredients of granite are blended into a finely granular mass. Crystals of quartz and mica are sometimes scattered through the base of eurite. *Pegmatite,* a name given by French writers to a variety of granite; a granular mixture of quartz and felspar; frequent in granite veins, passes into graphic granite. All these granites pass into certain kinds of trap, a circumstance which affords one of many arguments in favour of what is now the prevailing opinion, that the granites are also of igneous origin.

"It has already been hinted, that the heat, which in every active volcano extends downwards to indefinite depths, must produce simultaneously very different effects near the surface, and far below it; and we cannot suppose that rocks resulting from crystalizing or fused matter under a pressure of several miles of the earth's crust can resemble those formed at or near the surface. Hence the production at great depths of a class of rocks analogous to the volcanic, yet differing in many particulars, might almost have been predicted, even had we no plutonic formations to account for. How well these agree, both in their positive and negative characters, with the theory of their deep subterranean origin, the student will be able to judge by considering the descriptions already given.

"It has, however, been objected, that if the granitic and volcanic rocks were simply different parts of one great series, we ought to find in mountain chains volcanic dykes passing upwards into lava, and downwards into granite. But we may answer, that our vertical sections are usually of small extent; and if we find in certain places a transition from trap to porous lava, and in others a passage from granite to trap, it is as much as could be expected of this evidence.

"Granites," continues Mr. Lyell, "pass into certain kinds of trap, a circumstance which affords one of many arguments in favour of what is now the prevailing opinion, that the granites are also of igneous origin. The contrast of the most crystaline form of granite, with that of the most common and earthy trap, is undoubtedly great; but each member of the volcanic class is capable of becoming porphyritic, and the base of the porphyry may be more and more crystaline, until the mass passes to the kind of granite most nearly allied in mineral composition.

"The minerals which constitute alike the granitic and volcanic rocks, consist, almost exclusively, of seven elements, namely—silica, alumina, magnesia, lime, soda, potash, and iron; and these may sometimes exist in about the same proportions in a porous lava, a compact trap, or a crystaline granite, ... and, finally, it would be easy to multiply examples and authorities to prove the gradation of the granitic into the trap rocks."*

* Elements of Geology, vol. ii. pp. 324—348.

The following corroborative extracts are from Professor Phillips's Treatise:—

"Few parts of the globe, except some of the vast plains and deserts, are entirely deficient of rocks which are not stratified, though the surface which they occupy is not nearly so great as that covered by the strata. Granitic and basaltic rocks compose generally the greater portion of the unstratified masses, as in Britain, and lie in the same relations to the strata. Granitic rocks throughout the globe, constitute the most frequent axes or centres of mountain groups, and basaltic rocks fill dykes and spread in irregular cappings over the strata. It is evident, therefore, that the structure of the exterior parts of the globe, though full of local diversity, is all formed upon one general plan, and produced by similar agencies."

And again—

"*Igneous rock-veins.*—Besides the irregular granitic floor upon which all the gneiss and mica-slate system rests, and from which at many points, veins or interspersed beds pass up into these strata, many other masses of pyrogenous rock have been forced among the gneiss and mica-slate, so as to constitute dykes or irregular masses of large extent. Thus prophyry, greenstone, basalt, and other crystalized rocks are found mixed with the gneiss and mica-slate in various parts of the Highlands, Hebrides, and Zetland. Of these the most frequent is porphyry."

And in continuation—

"The state of the globe during the period of the production of the primary strata may never be fully disclosed by geological enquiries, even when aided by higher departments of knowledge: yet, as a view of the successive conditions of the globe, however imperfect, constitutes the very essence of philosophical geology, it is necessary to ascertain what progress has been made in this dark research, into some of the earliest natural records of creation. It is remarkable that the lowest of all the known systems of stratified deposits should be at once the most extensive, the most nearly universal, the most uniform in mineral character, the only one from which organic life appears to be totally excluded, and in which the character of mechanical aggregation is the most obscure. . . . . .

"In accordance with the úndoubted truth of the general expansion of rocks of igneous origin, below all the stratified masses, we naturally inquire if the agency of subterranean heat is of a kind to account for the phenomena observed."*

In further corroboration of this point, reference is particularly requested to a very neat and comprehensive passage from Professor Phillips's Treatise on Geology, already adduced, in evidence, on a kindred subject; and which bears very conclusively on that now under discussion†:—

"The reasons," says Dr. M'Culloch, "for believing that all the unstratified rocks are alike of igneous origin, or that they are substances crystalized from a fluid of fusion, will be given in a more proper place hereafter. . . . . As it is apparent that granite has been in a state of fluidity beneath the

* Treatise, pp. 42, 78, 79, 93, 94.
† Pages 68, 69. Also p. 126 of this work.

strata, and that, during this state, these have been elevated in an irregular manner, it is easy to account for the irregularity of its general surface, or for the partial way in which it is found distributed on the earth's superfices. The consequence of the unequal elevation of the strata was to produce those interior inequalities that have been filled by the yielding mass which was the immediate cause of that fracture, and the concomitant of the force exerted. The production of the veins is another obvious consequence of the fractures or discontinuities formed by the displacements of the strata.

"Since now the other division of the unstratified rocks is found above the strata rather than below, it is necessary to inquire respecting the origin of trap also. That it was produced in a fluid state, and consolidated from that condition, rests on precisely the same grounds as the case of granite. The nature of the different substances is similar, often identical, the effects are the same on the including strata, and the disposition of the veins is strictly analogous, varying only according to circumstances which have already been stated. Nor is trap exclusively superficial, since it is actually found beneath the strata in considerable masses, or else in such a relative position to them vertically as to resemble granite in this respect. . . . . . By the argument of dilemma, therefore, we must seek their origin in the same regions that produced granite. That this really is their origin, is further proved by the positive arguments derived from the masses that lie beneath, or among the strata, by the depth and magnitude of their veins, and by the marks of force which accompany their juxta-position to the strata. . . . . . It is in the deeper regions of the globe, therefore, in those where we have found the origin of granite, that we must seek that of trap. These substances are essentially of the same nature, but they have been produced at distant periods of time. . . . . . It must thus be apparent, that whatever differences may exist between trap and granite, whether in their relations to the strata, or their mineral characters, they are strikingly analogous in almost every essential general circumstance, and that the former may, in a certain sense, be considered as a recent granite; as the granite of the newer strata. . . . . . Thus it is proved that granite, or at least a rock originating in the same causes, may possess the characters of some of the most common varieties of the most recent traps. It remains to reverse the proposition, and to adduce instances of the granitic character among the recent unstratified rocks. . . . . .

"In the meantime I am unable to perceive that anything is wanting to prove the identity of origin in trap and granite. It is little likely, at least, that geology will often furnish us with evidence of a more decided nature.*

At another place he says—

"In examining the revolution of the earth, I have rendered it probable, that there has been granite, or an analogous substance, prior to all strata, and the original source of the whole."†

Professor Playfair states—

"Granite, the fossil now defined, exists, like whinstone and porphyry, both in masses and in veins, though most frequently in the former. It is,

* Geology, by Dr. M'Culloch, vol. i. pp. 145—160. It is recommended that the reader should refer to the work itself, and peruse the whole chapter, which could not be given any fuller here, although replete with interest.

† Geology, by Dr. M'Culloch, vol. ii. p. 196.

like them, unstratified in its texture, and is regarded here, as being also unstratified in its outward structure."

"Granite, it has been just said, exists most commonly in masses; and these masses are rarely, if ever, incumbent on any other rock: they are the bases on which others rest, and seem, for the most part, to rise up from under the ancient or primary strata. The granite, therefore, wherever it is found, is inferior to every other rock, and as it also composes many of the greatest mountains, it has the peculiarity of being elevated the highest into the atmosphere, and sunk the deepest under the surface, of all the mineral substances with which we are acquainted."*

These copious extracts will conclude the evidence, in favour of the acknowledged existence of an amorphous mass of mineral matter beneath all those formations which retain their stratified texture; and, likewise, of the diversified effects—shown by phenomena appreciable by the senses—which resulted from the general convulsion amongst those parts of the earth's crust, when it was caused to revolve around its axis, for the first time, by the formation of the light. This act of protorotation having, by centrifugal impetus, produced the universal movement above alluded to, and, in turn, caused the friction and consequent fierce heat which fused the mineral substances; and fitted them, in this condition, for irresistible protrusion into the rents, fissures, and centres of mountains and mountain chains, arising from the extension and breaking up of the earth's surface, to complete its static form of revolution; while the same centrifugal impetus, and the heat thus engendered, co-operated to impel these melted streams into the diversified apertures of enlargement, by which only they could find vent, and where alone they were required! Thus exhibiting another example of a complete chain of cause and effect, which links the external form, peculiar position, and internal structure of these rocks of igneous origin, to the creation of the light on the first day of the Mosaic week.

Thus far the Dynamical Theory successfully accounts for the earth's formation; but when we attempt to apply it, to ascertain the probable condition of these mineral ingredients, before they were made to issue forth, in universal streams, from almost every point of the globe, to insinuate and wedge themselves into the openings prepared for them, when it pleased the Creator so to arrange it; when this application is made of the theory, we are reminded, that it has more to do with *what is*, than with what *was*; and that it can assist only to infer the original condition of these hidden masses—hidden far beneath the accumulated deposits of the non-rotatory period—by the transformation which the dynamical forces have effected in them.

Perhaps, indeed, the greatest benefit which can be derived from these investigations, in relation to this branch of the subject, is the

* Playfair's Works, vol. i. pp. 95—97.

perspicuity with which they point to movement *inter se*, friction, heat, and centrifugal impetus—the inseparable concomitants of the Dynamic Theory—as the true cause of the difference between stratified and unstratified rocks, and of every diversified feature of these two great classes.

But even this points onwards, not backwards, and leaves the chief difficulty untouched. There is still a necessity for supposing the existence of some universal sub-stratum, on which deposition first began, and which possessed more cohesion than would be produced by mere juxta-position of particles, such as sand, for it had to receive the deposits from the primitive ocean, which now constitute the strata; and to sustain them for countless ages upon its bosom. Although, on the other hand, the particles of this sub-stratum must have had sufficient mobility to have admitted of their being put into motion, and conducting themselves in all respects as a semi-fluid or ductile mass, even before they were reduced to that state by heat resulting from friction; for this could only *follow*, but could not *precede* their motion; while, to add to the difficulty, their present crystalized texture forbids the supposition of partial previous fluidity having been produced by water; for, if this had been the case, its subsequent evaporation, when driven off in the process of crystalization, would most assuredly have left these primitive rocks much more porous than they are found to be.

Indeed, the more all the phenomena attending the elevation of continental ridges, and the depression of oceanic hollows, which seem to reveal a state of mysterious elasticity in the internal regions of the globe, are considered, and also, the scrupulous economy of means to the end everywhere observable in the works of the Creator, while under the conviction, that the earth, like all the heavenly bodies, is destined to be a pedestal to *uphold upon its surface*, not a receptacle for containing *within*. When all these motives for a hollow or cavernous structure, with the apparent necessity, according to the observations of some astronomers, of internal density, are contrasted, greater difficulty than ever is experienced in coming to a determination, an uncertainty by no means lessened, although certainly left open to discussion, when such different opinions upon this very subject, as those I am about to subjoin, are maintained.

The accomplished author of *The Connexion of the Sciences* says—

"But a density so extreme, is not borne out by astronomical observation. It might seem to follow, therefore, that our planet must have a widely cavernous structure, and that we tread on a crust or shell whose thickness bears a very small proportion to the diameter of the sphere. Possibly, too, this great condensation at the central regions may be counterbalanced by the increased elasticity due to a very elevated temperature."*

"It has sometimes," says Professor Whewell, "been maintained by fan-

* Connexion of the Sciences, p. 90.

ciful theorists, that the earth is merely a shell, and that the central parts are hollow. All the reasons we can collect, appear to be in favour of its being a solid mass, considerably denser than any solid rock."*

"Taking water at a temperature of 60° as the unit of comparison," says Professor Phillips, "we find the specific gravity of the superficial parts of the globe, as judged of by weighing the most prevalent rocks, to be 2.5. By direct experiment, and comparison of the local attraction of mountains and insulated masses of matter with the general attraction of the globe, the mean density of our planet has been inferred to be about five times that of water. This result is found sufficiently in accordance with astronomical considerations, to allow us to adopt it for geological reasoning.

"The interior parts of the globe must therefore be denser than the exterior rocks.

"From the influence of the earth on the moon's motions, it is inferred, that the internal mass of our planet augments in density towards the centre; the surfaces of equal density being symmetrical with the external spheroidal surface. The materials of the earth have therefore collected round the centre in obedience to the laws of gravitation and rotatory movement, and the internal substances, as having fallen to the lower place when freedom of motion was allowed, would probably be heavier under the same circumstances than the superficial substances, and so forth. . . . . . Now though we cannot presume that the laws of compression would hold in these bodies to such an extent, enough is known to justify a confident belief, that the mean density of our planet would be very much greater than it is, were not the tendency to enormous condensation in the central masses counteracted by some powerful agent of expansion, such as heat, or neutralized by some peculiar or unknown constitution of the substances themselves."†

Dr. M'Culloch, when treating incidentally on this, says—

"Notwithstanding its inferiority in position, we must not grant, as asserted, that granite constitutes the mass of the globe, or is the lowest rock in existence. Of the interior of the globe we know nothing; but its weight is sufficient to prove, that it is not formed of granite. . . . . . Some unstratified matter, solid or fluid, does doubtless lie beneath the stratified surface of the earth; but while conjectures are fruitless, it might, if solid, be basalt as well as granite."‡

How infinitely would the assumption of Mrs. Somerville, if eventually found to be correct, tend to exalt our ideas of the wisdom, and the power of the Creator, who disposed and prepared the rocky shell in such a way, that while, by his command, it was transformed, from a level sphere, "without form and void," into a spheroid, adorned with continents and ocean beds, hills and dales, yet was so cemented and welded together, in the very act of its transformation, that neither the elastic fluids were permitted to escape from within, nor the water to penetrate the superficial crust! But, as before remarked, while this recondite point in cosmogony is shut up from experimental investigation, and thereby exposed, less or more, to

* Bridgewater Treatise, p. 50. The remaining part is recommended to the perusal of my readers.

† Treatise on Geology, pp. 9—11.

‡ Vol. ii. p. 87.

conjecture, its importance seems to be inversely as the difficulty of its determination. The earth's formation can be satisfactorily accounted for even should this be assumed, merely in conformity with the requirements of interplanetary laws.

Nevertheless, I take occasion to observe, that this abstruse question has been so far benefitted by the Dynamical Theory, that this has removed the seeming necessity which there appeared to be, for not only taking fierce *internal heat* into the resolution of the problem, but for subordinating all the other conditions to this datum, supposed to be so well established. Henceforward, it is to be hoped, that the heat, discoverable in mines and other perforations, will be attributed to that which was caused by the friction of the moving mineral masses, during the earth's protorotation, and whose foci resided in mountain nucleii; as this of itself is quite sufficient to have produced the phenomena in question; while the Dynamical Theory would have been incomplete without the existing demonstrations of heat in these localities, continued to the present day from the period of the earth's protorotation.

SECTION V.

GEOLOGICAL PHENOMENA RESULTING FROM THE EARTH'S PROTOROTATION.

CHAPTER XXV.

The immediate consequences of the two established positions: the non-rotation of the earth until all the strata, up to the coal measures, had been formed; and its subsequent protorotation, considered with reference, firstly, to the rush of water which took place from the poles towards the equator; and, secondly, to the disintegration which accompanied the upbursting of the amorphous rocks, during these violent movements of the primitive water. This conflux of water attempted to be explained analogically by currents of wind; and applied to the peculiar case under consideration. The attention then directed to another simultaneous series of events. The upbursting of the amorphous masses, and the disintegration which must have ensued, together with the disseminating effects of the violent aqueous currents towards the equator. Geological evidences. Some brief concluding observations.

Having thus established the fundamental positions, That the earth existed in a state of non-rotation during a period sufficiently long to admit of the deposition of all the stratified formations up to the completion of the coal measures; and, that its protorotation took place on the first day of the Mosaic week; I have, in continuation, to consider two of the more important of the manifold consequences which resulted from the commencement of the earth's diurnal motion at the period alluded to. These are so intimately allied to each other in the effects which they, in turn, produced on the geological developments of the earth, that it would be most desirable could they, by any means, be described simultaneously, but this is not possible, and therefore they will be considered in immediate sequence. I allude, firstly, to the rush of water from the polar seas towards the equatorial regions to complete the figure of equilibrium; and, secondly, to the comminuting and disintegrating influence conjointly of this sudden movement of the water, and the upheaving of the unstratified masses, when they burst through the strata in consequence of the centrifugal impetus occasioned by the first rotation of the earth around its axis.

A rush of water, similar to that which is here alluded to, never having been thought of by philosophers, no provision has been made for it; and, therefore, in place of being able to produce direct

testimony to show what would be the consequences of a world of water being thus thrown into sudden and violent movement, and sweeping over rocky masses in the act of disintegration and comminution, and also in agitation, I am necessitated to reason by analogy, and to adopt the case which nearest approaches to it. The clear and convincing exposition which has been given of the trade winds, is found to be very analogous, and suitable for this purpose, the appropriate points of which compose the *thirty-fifth* Theorem, which states, "*That a satisfactory explanation of the trade winds has been given upon certain well-known and established principles, amongst which the following are relevant to the present subject:* 1*st. That all portions of the earth's surface have a velocity of rotation in direct proportion to the radii of the circle of latitude to which they correspond;* 2*nd. That the air, when relatively and apparently at rest, is only so because it participates in the motion of rotation proper to that part of the earth;* 3*rd. That, consequently, when currents of air set towards the equator from the north or south, they must lag, hang back, or drag upon the surface, in a direction opposite to that of the earth's rotation, or from east to west; and, lastly. That the polar currents, from a deficiency of rotatory velocity, tend by their friction, near the equator, to diminish the velocity.*"

The following evidences corroborate the truth of this interesting Theorem; they are necessarily restricted to the points which alone affect this theory:—

"Another great geographical phenomenon, which owes its existence to the earth's rotation, is the trade winds. These arise from, 1st, the unequal exposure of the earth's surface to the sun's rays, by which it is unequally heated in different latitudes; and, 2ndly, from that general law in the constitution of all fluids, in virtue of which they occupy a larger bulk, and become specifically lighter when hot than when cold. These causes, combined with the earth's rotation from west to east, afford an easy and satisfactory explanation of the magnificent phenomena in question. . . . . .

"Since the earth revolves about an axis passing through the poles, the equatorial portion of its surface has the greatest velocity of rotation, and all other parts less in the proportion of the radii of the circles of latitude to which they correspond. But as the air, when relatively and apparently at rest on any part of the earth's surface, is only so because in reality it participates in the motion of rotation proper to that part, it follows, that when a mass of air near the poles is transferred to the region near the equator, by any impulse urging it directly towards that circle, in every point of its progress towards its new situation, it must be found deficient in rotatory velocity, and therefore unable to keep up with the speed of the new surface over which it is brought. Hence, the currents of air which set in towards the equator from the north and south must, as they glide along the surface at the same time, lag, or hang back, and *drag upon it* in the direction *opposite* to the earth's rotation, *i. e.* from east to west. Thus these currents, which but for the rotation would be simply *northerly* and *southerly* winds, acquire from this cause a *relative* direction towards the *west,* and assume the character of permanent north-easterly and south-easterly winds. . . . .

It follows, then, that as the winds on both sides approach the equator, their easterly tendency must diminish. The length of the diurnal circles increase very slowly in the immediate vicinity of the equator, and for several degrees on either side of it hardly change at all. Thus the friction of the surface has more time to act in accelerating the velocity of the air, bring it towards a state of *relative* rest, and diminishing thereby the relative set of the currents from east to west, which, on the other hand, is feebly, and at length not at all reinforced by the cause which originally produced it. And arrived at the equator, the trade winds must be expected to lose their easterly direction altogether. . . . . . All these consequences are agreeable to observed fact, and the system of aerial currents above described constitute in reality what is understood by the regular *trade winds*."*

This will be found to be fully corroborated by the following observations of Mrs. Somerville:—

"In consequence of the combination of all these circumstances, given in the context, two great currents, in the ocean, perpetually set from each pole towards the equator. But, as they come from latitudes where the rotatory motion of the surface of the earth is very much less than it is between the tropics, on account of their inertia they do not immediately acquire the volocity with which the solid part of the earth's surface is revolving at the equatorial regions; from whence it follows, that within 25 or 30 degrees on each side of the line, the ocean appears to have a general motion from east to west, which is much increased by the action of the trade winds."

And again—

"Although the attraction of the sun and moon has no sensible effect on the trade winds, yet, the heat of the sun occasions those aerial currents, by rarefying the air at the equator, which causes the cooler and more dense part of the atmosphere to rush along the surface of the earth to the equator, while that which is heated is carried along the higher strata to the poles, forming two counter currents in the direction of the meridian. But the rotatory velocity of the air, corresponding to its geograghical position, decreases towards the poles. In approaching the equator, it must, therefore, revolve more slowly than the corresponding parts of the earth, and the bodies on the surface of the earth must strike against it with the excess of their velocity, and by its reaction they will meet with a resistance contrary to their motion of rotation. So that the winds coming from the polar regions, will appear . . . . to blow from the north-*east* on the one side of the equator, and from the south-*east* on the other, which is the direction of the trade winds."†

* Astronomy, by Sir John Herschel, Cab. Cyc. pp. 128—132.

† Connexion of the Sciences, pp. 115, 137.

Note.—With manifest allusion to the rush of water which occurred from the polar towards the equatorial regions of the earth on its first rotation taking place, there are two sublime passages in Scripture: one in the Book of Job, another in the Psalms, and, however distinct they may be from philosophical evidence, I cannot refrain from giving them in this note; the more so, as, in the absence of *direct* proof, or that which is appreciable by the senses, the testimony of Him who only could know what then took place, can alone be appealed to. "Where wast thou," demands the Almighty of his afflicted servant, "when I laid the foundations of the earth? declare, if thou hast understanding. . . . . . Who laid the corner-stone thereof? . . . . . . *Or who shut up the sea with doors, when it brake forth as if it had issued out of the womb?*

Applying these quotations, relating to the trade winds, to the case under consideration, namely, a primitive circumfluent ocean of uniform depth, reposing in its *then* static condition of spherical equilibrium upon the non-rotating world; and conceiving the whole to have been put suddenly into motion from West to East, with an angular velocity of 15° per hour, it is evident, that in order to regain the state of rest from which the water had been aroused, and to which it would seek to return, it would hasten to assume the level of form which corresponds to equilibrium under rotation; that is, such a change would be produced in the entire mass, as would have the effect of raising the water of the equatorial regions thirteen miles above the level of those at the poles; or what is the same, a line passed through the equatorial ocean, would measure twenty-six miles more from surface to surface, than a diameter taken of it from pole to pole.

To acquire this form of equilibrium there would, of course, be a transfer of water from the polar to the equatorial regions; and, as this transformation was effected in forty-eight hours, the velocity of the current would be inconceivably violent; while its retardation, or lagging behind, from the difference of velocities in the aqueous zones, corresponding to the radii of the circles of latitude, as the water hastened towards the equator, would be correspondingly great. Consequently, as in the case of the trade winds, instead of forming a direct southerly current from the North Pole, and a northerly one from the South Pole, that overwhelming rush of water would assume a *westerly* direction as it approached the equatorial regions from both of these extremities, and thus tend to mitigate the centrifugal impetus of the inter-tropical ocean; which, although of the same specific gravity as the more distant seas, would, from the form and rotation of the earth, be unavoidably subjected to a much more intense degree of centrifugal impetus; and might have been, but for this provision wisely ordained to counteract it, withdrawn from the influence of attraction, and whirled off the surface of the globe!

From the very lucid explanations which have just been given, of the origin of the trade winds, it will have been observed, that one of the procuring causes is the inertia of the atmosphere, or, in other words, the earth's attraction causing it to adhere to and perform rotatory motion, corresponding to its *geographical* position, or the

When I made the clouds the garment thereof, and thick darkness a swaddling-band for it, and brake up for it my decreed place, and set bars and doors, and said, Hitherto shalt thou come, but no further; and here shalt thy proud waves be stayed." (Job xxxviii. 1—11.) And again, "Who laid the foundations of the earth, that it should not be removed for ever? Thou coveredst it with the deep as with a garment: the waters stood above the mountains. At thy rebuke they fled: at the voice of thy thunder they hasted away. The mountains ascend, the valleys descend into the place which thou hast founded for them. Thou hast set a bound that the waters pass not over; that they turn not again to cover the earth." (Psalm civ. 5—9.)

zones of latitude where the wind is; and, as in the immediate context to this *rationale* which Sir John Herschel gives of this interesting natural phenomenon, there is the following rule—that "the weight of a body (considered as undiminished by centrifugal force), is the effect of the earth's attraction on it"—it follows, as a matter of course, that this action, on the part of the earth, *is as much more powerful on water as it is on air, in proportion as water is heavier than air;* and, consequently, this *lagging* or *westerly* direction in the rush of *water* from the poles towards the equator would be much more certain and excessive than what is now experienced to be the case with the trade *winds*.

Counteraction, however, was only one of the many important services which this mighty rush of water was designed to perform. But as it is essential to unfold other effects which were simultaneously taking place, in order that the co-resultant consequences may be thoroughly and more easily comprehended, this particular branch of the subject will be left, for the present, in the state in which it has been placed, with the intention of being resumed shortly hereafter; while it is merely observed, that no one can avoid being vividly impressed with admiration and astonishment at the power and the wisdom of that Omnipotent Being, who could thus "mete out the oceans in the hollow of his hand, and wield them at his sovereign pleasure!" Who could "set bars and doors unto them," and say "hitherto shalt thou come, but no further, and here shall thy proud waves be stayed!"

The attention has in the meantime to be directed to another series of events which were going forward contemporaneously with those which have lately been described. I allude to the disintegrating and comminuting effects of the protruded rocks, as they burst through their overlying stratified envelopes; and spread about, with explosive violence, an immense body of *debris* of all descriptions, from the massive boulder to the impalpable soil; swept away instantaneously by the water, and destined to form newer and unconformable strata in the rugged hollows occasioned by the elevation of the mountains which caused the disintegration.

In a former part of this section the increase of surface which the earth underwent, on being transformed from a sphere to a spheroid of rotation, was estimated at upwards of *eight hundred and sixty-one thousand square miles*, by a computation of plane surfaces. It will also be remembered, that the part at present covered by the ocean, is in proportion to that which is dry, as 3 is to 1; therefore, it should justly be considered, that only one-fourth of the above increase of surface pertains to the present continents; or to that portion, which being above the level of the ocean, may be subjected to geological investigation. But the great bulk of the increase which the globe experienced having been within a zone of from thirty to thirty-five degrees on each side of the equator, where the centrifu-

gal impetus was most felt, and where the land is in greater proportion, impartiality demands that a more liberal concession should be made; it will, therefore, be considered, that the portion above the level of the ocean underwent an aggregate increase equal to one-half of the above quantity, or about *four hundred and thirty thousand square miles.*

The entire surface of the globe, computed from its two given diameters, is 196,878,115 square miles; consequently, its portion above the level of the sea, even taken at one-fourth part, is, in round numbers, *forty-nine millions two hundred and twenty thousand square miles,** which stands to the supposed portion of the enlarged surface last mentioned, in the proportion of about 1 to 115. It is very difficult, if not altogether impossible, to determine the exact proportion which the aggregate surface of *protruded rocks of all descriptions* bears to that which is still covered by the original stratifications; and the more so, as much space was covered over, and consequently hidden from examination, by the very *detritus* whose existence it is at present sought to substantiate; but certainly an impartial review of the geographical outlines of the earth's surface will convince any one, that the proportion of a *one hundred and fifteenth part* for unstratified and other protruded rocks, sinks into insignificancy when compared with what is actually known to be their true proportion.† In prosecuting this argument, it is clearly to be understood, that according to the principles of the present theory, not only the unstratified masses of every description, but likewise all strata which are tilted out of horizontality, are to be considered *protruded rocks,* from their now occupying a part of the surface formerly covered by the concentric layers of the ancient world; and consequently by their having added to the general disintegration.

It may easily be imagined with what satisfaction I find myself enabled, whilst in such a difficulty as this, to adduce the evidence of so shrewd and intelligent a writer as the commentator of Hutton, on a point of so hypothetical a nature, *as the supposed proportion which the primary rocks bear to the others;* and it is a still more fortunate circumstance, that where this is elicited in his writings, it should have been with a view to vindicate his friend from a charge brought against him by Mr. Kirwan, of having *underrated* the proportion which granite bears to other rocks, for, on that account, it is to be presumed, that *he would not admit one square mile of surface into his computations, which could, consistently with truth and justice, be excluded.* Therefore, his evidence must be

* I have much pleasure in stating, that these calculations have been examined and confirmed by Lieut. Alexander R. Clarke, of the Royal Engineers, and can therefore be thoroughly relied on, my young friend's acquirements in such questions being well known.—AUTHOR.

† Professor Phillips estimates the proportional surface covered by strata horizontal, or nearly so, at three-fourths the whole area. Page 59.

considered quite impartial when brought forward to substantiate an argument, during which, a desire to carry my point might probably have led me into the opposite error, even should there be any one foolhardy enough to entertain a suspicion of the correctness of Prof. Playfair's statements, trained as he was to the investigation of truth in its most abstract form. But to proceed—

"A remark," says he, "which Dr. Hutton has made on the quantity of granite that appears at the surface, compared with that of other mineral bodies, has been warmly contested. Having affirmed that the greater part of rocks bear marks of being formed from the waste, and decomposition of other rocks, he alleges that granite (a stone which does not contain such marks) does not, for as much as appears from actual observation, make up a tenth, nor perhaps even a hundredth part of the mineral kingdom. Mr. Kirwan contends that this is a very erroneous estimate, and that the quantity of granite visible on the surface, far exceeds what is here supposed. The question is certainly of no material importance to the establishment of Dr. Hutton's theory; it is evident, too, that an estimation, which varies so much as from a tenth to a hundredth part, cannot have been meant as anything precise; yet, it may not be quite superfluous to show, that the truth probably lies nearer to the least than to the greatest of the limits just mentioned."

After observing that the extent of surface occupied by granite in the immediate vicinity of Mont Blanc, does not exceed one-tenth part of the rocky surface; that none is found in the route across by Mount Cenis; that in other parts of the Alps it is about one-sixth; throughout the Pyrenees it may be estimated at one-fifth part of the whole mountainous part; he concludes, on the whole, that the proportion of granite to schistus, is that of one to four, and then goes on to give the evidence which more immediately affects our present argument, in the following words—

"It remains," says he, "to form a rough estimate from maps and from the accounts of travellers, as to what proportion of the earth's surface consists of primary, and what of secondary rocks. After supplying the want of accurate measurement, by what appeared to me the most probable suppositions, I have found, that about *one-eighteenth part* of the surface of the old continent may be conceived to be occupied by primitive formations, of which, if we take one-fifth we have a *ninetieth* for the part of the surface occupied by *granite rocks,* which differs not greatly from the last of the two limits assigned by Dr. Hutton."*

It must be observed, that in Dr. Hutton's theory, the primary strata comprehended, "besides gneiss, the micaceous chlorites, hornblend, and siliceous schistus, together with slate, and some other kinds of argillite," also "talcose schistus, and lapis ollaris, or potstone."† These, together with the granitic rocks, are included in those which he considered occupying *one-eighteenth* part of the surface of the old continent. But as the present object is to determine, if possible, the extent of *the protruded rocks of every description,* the

* Professor Playfair's Works, vol. i. pp. 341—344. † Ibid, pp. 29, 170.

preceding data are only available in having fixed a determinate proportion of surface occupied by certain known rocks of the primitive class, and as to them are to be added, not only the trap, porphyritic, and greenstone veins and dykes; the old red sandstone and the mountain limestones; but even the coal measures themselves, wherever out of horizontality, and appearing at the surface; the above fraction of one-eighteenth may, on their account, and on that of the whole protruded rocks of every denomination, be so far augmented in value, as that their aggregate extent shall be estimated at about *one-thirteenth* of the exposed surface; which is, certainly, a moderate proportion, as may be perceived by surveying any geological map of extensive area.

Assuming, then, the dry surface of the whole globe, as before stated, to be 49,220,000 square miles, one-*thirteenth* of it is somewhat more than *three millions seven hundred and eighty-six thousand square miles* of surface measurement, over which it is estimated that the protruded rocks extended themselves when they burst through the superincumbent strata; and, therefore, an equal number of square miles of stratified rocks, which have disappeared or been tilted up from the position of horizontal continuity they once occupied, require to be accounted for, or, in other words, it must be shown how this vast space was filled up by intruded rock, in order that the Dynamical Theory may not be considered imperfect.

It must appear evident to every reflecting mind, that owing to the manner in which the stratified masses were removed, and the violence with which the others were thrust into their places, through such great depths of aggregated layers of strata, immense disintegrating and comminuting effects must inevitably have ensued. I mean, even beyond those which produced the breccias and conglomerates lately treated of. Indeed, in many instances, the strata must have been ground down to an impalpable powder; while in others, both they and the protruding rock would be broken into fragments of every conceivable dimension, from the smallest gravel to the most massive boulder; and, altogether, there would be such an explosion—a tumultuous explosion of rocky material, as the world never witnessed before: nor, as long as time continues, will it ever witness again!

It is only after having been made aware of the prevailing extent of this catastrophe, that we are enabled to perceive, in its full extent, the consummate wisdom, and the harmony of design on the part of the Omnipotent, *in providing a rush of water all over the globe at this precise and important juncture.* Had the operations thus attempted to be described, been conducted without the presence of water, the rocky and stony *debris* would, by their natural gravity, have accumulated around the bases of the protruded hills in rugged, unconnected, and unproductive tumuli, as is the case in the vicinity of modern volcanoes; while, on the other hand, had the water not

been in violent agitation and motion, the subsidence of the mineral debris would have been much too immediate, and the effects it was destined to produce would have been left almost wholly unaccomplished. But, by the union of these two conditions, the mineral and earthy materials, deprived by the water of a great proportion of their specific gravity, were borne along in mechanical suspension with inconceivable rapidity, and spread over the rocky hollows formed by the elevation of the masses which occasioned the spreading abroad of that very mineral material destined to round off their scarped and rugged half-formed scenery—such as it is supposed to have been up to this date—and to render the earth's surface a more choice habitation for man and the animals which were soon thereafter to be willed into existence. Whilst it ought to be observed, as one of the most opportune and wise arrangements in this wonderful operation, that "the lagging of the waters" as they reached the equatorial regions, not only moderated the rush of those within that zone, but the meeting of the two currents brought the united flood sooner to rest, and enabled the converging torrents more instantaneously and more effectually to discharge themselves of their loads of earthy matter with which they had been despatched thither from their respective polar extremities; when the protorotation allowed them no longer to slumber around these newly-formed pivots of the earth. So wonderful are the works, and so harmonious are the designs of the Creator!

A complete corroboration of the view here adopted of the origin of this unconformable series of rocks, is given by M. de la Beche, when summing up his opinion of the new red sandstone group.

"If," says he, "we abstract our attention from its sub-divisions and regard the group as a mass, it would seem to constitute the base of a great system of rocks, which, when not deranged by local influences, has filled up numerous hollows and inequalities of land. . . . . United with the great capping of the oolitic group, which for the most part rests so conformably upon it, they, together, would seem to fill up great depressions in Europe. . . . . . During their deposit great and remarkable changes were effected in animal and perhaps in vegetable life. Very extensive tracts of red sandstone exist in Mexico and South America, but whether contemporaneous with those of Europe, the state of science does not permit us satisfactorily to determine. The porphyries and slates of New Spain are surmounted by red conglomerates and sandstones, forming the plains of Celaya and Salamanca. . . . . . In Venezuela the vast plains are, in a great measure, covered by red sandstones and conglomerates deposited in a concave manner between the coast mountains of Caraccas and those of Parima. . . . . . An immense extent of red sandstone is described as covering nearly without interruption the southern plains of New Granada, the basin of Rio de la Magdalena, and Rio Cauca, between Carthago and Cali. . . . . . According to Humboldt, the Cordilleras of Quito presented him with the greatest extent of red sandstone which he had observed, covering the whole plateau of Tarqui and Cuenca for twenty-five leagues; and the same also occurred,

he adds, in Upper Peru, while he remarks on the resemblance of these rocks of Mexico, New Granada, Peru, and Quito, to the red sandstone, or *Todtliegendes* of Germany. . . . . .

"A series of red sandstones intermixed with conglomerates also occurs extensively in Jamaica. . . . . . These rocks appear to be the equivalent of those named red sands in the neighbouring continent of America. . . . . The mere mineralogical resemblance of this deposit in America and Jamaica with the sandstones and conglomerates of the red sandstone group of Europe is in itself of no great value, and, therefore, we can only at present conclude, that considerable forces have been exerted in both parts of the world (whether contemporaneous or not remains to be determined), which have dispersed fragments of pre-existing rocks, scattering them, most probably by the medium of water violently agitated, in various directions, the transporting powers being unequal, so that sandstones and marls alternate with conglomerates; so that, if different deposits have not been confounded under one head, those sandstones and conglomerates would appear, not the result of a limited disturbance, but of one common to a considerable surface."*

Professor Phillips confirms this when he says—

"The next succeeding deposit, which receives the name of red sandstone, or saliferous, or poecilitic formation . . . . . almost universally fills a low or level country, out of which arise insulated groups and short ranges of mountains of old strata or of pyrogenous rocks. . . . . . The system consists of many alternations of arenaceous and argillaceous members, with some less continuous interpositions of limestone usually impregnated with magnesia. . . . . . Thus the whole is capable of being represented in one formula, which is well calculated to show both the agreement and differences usually observed in comparing distant parts of a stratified formation."† . . . . .

"Salt is associated with the upper parts of this system in England, France, and Germany, where the muschelkalk is quite as saliferous as the variegated marls to which, apparently, salt is confined in England. Upon the whole, therefore, the red sandstone system is a vast mass of sandy and argillaceous sediments of a peculiar aspect, accompanied more than any others yet known by salt and gypsum, generally deficient in organic remains, and only locally enclosing strata of limestone, which commonly are characterized by abundance of magnesia."‡

The denuding and sweeping action of a vast body of water seems, by the following passage from Mr. Miller's work, to have likewise been recognised by him in the geological developments of those parts which he examined :—

"The curtain again rises," says he, "a last day had at length come to the period of the middle formation; and in an ocean roughened by waves and agitated by currents, like the ocean which flowed over the conglomerate base of the system, we find new races of existences. . . . . . The depositions of this upper ocean are of a mixed character; the beds are less uniform and continuous than at a greater depth. In some places they consist exclusively of sandstone, in others of conglomerate; and yet the sandstone and conglomerate seem, from their frequent occurrence on the same

* Manual of Geology, by M. de la Beche, 2nd edition, pp. 409—412.

† I would recommend my readers who may have the opportunity to refer to this formula.

‡ Treatise, pp. 119, 120, 123.

platform, to have been formed simultaneously. The transporting and depositing agents must have become more partial in their action than during the earlier period. They had their foci of strength and their circumferences of comparative weakness; and while the heavier pebbles which compose the conglomerate were in the course of being deposited in the foci, the lighter sand which composes the sandstone was settling in those outer skirts by which the foci were surrounded. At this stage, too, there are unequivocal marks, in the northern localities, of extensive denudation. The older strata are cut away in some places to a considerable depth, and newer strata of the same formation deposited unconformably over them. There must have been partial upheavings and depressions, corresponding with the partial character of the depositions; and, as a necessary consequence, frequent shiftings of currents. The ocean, too, seems to have lessened its general depth, and the bottom to have lain more exposed to the influence of the waves."*

In a former part of this work, allusion was made to one very important service performed by the *debris* here spoken of, namely, *protection to the vegetable beds which now constitute the principal coal fields.* It not only saved these from being washed away by the denuding influence of the water thus thrown into violent movement, but by covering them, it likewise preserved them effectually from the atmosphere which was shortly afterwards to be formed, and by confining their gaseous ingredients, rendered them fit for their present purposes, as great carbonaceous deposits. It must also be added, that another very wise and beneficent design was carried into execution, by the arrangement which impelled the water from the poles towards the equatorial regions. In the latter zone, the mountains having risen to a greater height by the increased centrifugal impetus, a proportional quantity of loose, stony, and earthy material would necessarily be requisite to fill up their deeper hollows, and more rocky and rugged acclivities; but as, at that period, the aggregate depth of the strata was uniform all over the spherical earth, it is evident, that the mere elevation of the protruded rocks, although to greater heights, would not have been sufficient to have supplied the *debris* required for that purpose. Hence, in the sudden rush of water, laden with earthy materials from either pole, towards the equatorial regions, and it being there brought to rest and made to unladen itself of its burden, we behold a wise and harmonious combination; wherein the several circumstances are made to concur towards the completion of the design then in contemplation. Nothing could have been better adapted for supplying the wants in these regions, and for completing the habitable portions of its surface, than this seasonable supply of earthy matter, borne along by the rushing water, and deposited where it was so much needed; while, by the same process, the more extreme latitudes were relieved, by disintegration and denudation, from an immense mass of loose material, which would have been

* Old Red Sandstone, pp. 310, 311.

positively prejudicial where it was originally formed, had it been *there* re-deposited.

Other attendant circumstances, displaying the infinite wisdom of the whole design, ought, by no means, to be overlooked. In the first place, the modified state of the oceanic water itself, which, during a protracted course of preparation, had been deprived of the greater part of those previously combined gases, which, had they been permitted to exist in the water until the period now referred to, would have re-dissolved the earthy material which was designed to be merely mechanically disseminated throughout it; and, by demanding a fresh chemical process, have been inimical to the intention then in view, of mechanical suspension only, and almost instantaneous deposition. Next the admirable adaptation of the agent employed for effecting, in the most appropriate manner, the deposition of the earthy material, which was thus sent to make a smooth and habitable soil, from a heterogeneous mass of boulders, fragments, gravel, sand, and finely comminuted earthy soil; as it must be obvious, that according to the laws affecting them, they would be deposited from the liquid carrier in proportion to the sizes of the fragments, particles, &c., and thus the asperities would be rounded off at the same time that the land itself was formed. Similar reasons will also explain how the more massive boulders, in many instances, would be deposited near to the site of their parent rocks, while the finer particles would be conveyed, even to within the tropics, to fill up and form the extended table lands of these regions, and constitute those almost interminable depths of light calcareous soil, which so frequently characterise those elevated plains, across whose broad and fertile surface it has so often been my lot to travel; and to view with wonder and amazement the great depth of the accumulated soil, sand, and gravel, exposed by deep ravines, and laid bare by the river courses when these were reduced to rivulets during the dry season.

It will have been observed, that in these investigations, no notice whatever is taken of the saliferous deposits which, so generally, are associated with these widely-spread arenaceous formations; it is my intention to treat very fully of these in a subsequent part of this work, after having explained the formation of the atmosphere, according to the Dynamical principles of this theory. Neither has any allusion been made to the remaining three-fourths of the earth's surface, or the part which constitutes the bed of the ocean. Over all that area, no doubt, somewhat similar events would be taking place to those which were occurring on the terrestrial portion of the globe; but as the *debris* occasioned in the oceanic part would be precisely proportioned to the surface over which it was spread, the quantities being equal, in both terms of the equation, they can be eliminated, or disregarded entirely, without affecting the correctness of the general argument.

SECTION V.

GEOLOGICAL PHENOMENA RESULTING FROM THE EARTH'S PROTOROTATION.

CHAPTER XXVI.

The previous subject continued. Formation of Earths and Soils. The attendant circumstances peculiarly favourable for this needful process. The unconformable rocky masses which overlie the coal measures. Geological evidence of their existence. Enquiry into their origin, as made known to us by the Dynamical Theory. Geological character of the newer Secondary suites. The New Red Sandstone, the Oolitic, and the Cretaceous groups. Their saliferous associates reserved for a future Section. The Supra-cretaceous deposits, as explained by this Theory, and the clear line of demarcation which it draws between them and the still more recent surface accumulations, the residium of the Deluge.

To make manifest that everything was arranged by infinite Wisdom, and all the attendant circumstances made to conspire towards the completion of the plan of creation, then progressively and rapidly being unfolded, I shall, at this opportune juncture, direct the attention to the nature and formation of *earths and soils*. To do this, it will be merely necessary to recapitulate, in succession, the Theorems which have reference to these substances. The subjects they treat of being quite of an elementary character, it is not considered requisite to detain the general argument by bringing forward their evidences; reference may therefore be made to their respective authorities, should any doubts be entertained, or further information required on the subject. In passing, however, I take occasion to mention, what may perhaps not be so generally known, namely—that some celebrated French chemists have discovered, and satisfactorily proved, that when the contained oxygen has been doubled in water, its oxydizing power is greatly augmented, the oxydation, and consequently the formation of the bases of earths, when it is in this state, going on with a rapidity almost inconceivable. Having made this advertency, I hasten to unfold the general outlines of this additional and conspicuous instance of that provident forethought and wisdom which made all things work together for the accomplishment of one great design. In the present instance the

chief object having been the formation of an appropriate bed of earthy soil, to receive and sustain that rich and magnificent vegetable covering composed of an attractive variety of foliage, of flowers, and of fruits, which was so soon to be thrown over and to adorn the new formed land. The *ninety-eighth* Theorem states, "*That earthy matter consists generally of some metallic substance in chemical combination with oxygen, forming an oxide. That the combination of earthy metals with oxygen usually takes place when favoured by a sufficient elevation of temperature. That this constitutes the important change which many metals undergo when heated under exposure to the air. And that, to facilitate this combination, it is necessary to raise their temperature considerably, to some metals it being even requisite to apply very intense heats.*"

When we reflect on the stupendous chemical process then going on, the introduction of heated continents and mountains abounding with metals and metalloids, into the midst of a universal ocean, plentifully saturated with oxygen, and take into account the increased powers of oxydation which water possesses when its associated oxygen is augmented, we are forced to exclaim, This indeed was a laboratory worthy of the Creator, when producing the materials for the soils of a world! Any observations here on a subject such as this would be wholly superfluous. To those who can appreciate its magnificence they will be unnecessary; to those who cannot they would be of no avail! I shall, therefore, go on to exhibit the manner in which these earthy oxides are generally removed from where they are formed; and, last of all, enumerate the remaining substances which contribute to the formation of perfect soil.

The manner in which sands and soils are at present formed is under atmospheric influences. Although the atmosphere, and consequently, none of its meteorological changes, were in existence at the period now alluded to, yet it is presumed that in the primitive ocean, abounding with carbonic acid and free oxygen, thrown into violent motion and agitation, there existed elements in every respect equal in effect, and superior in power, to those which are now in daily operation for repairing the continual waste of soil absorbed in vegetation, and swept into the ocean by rains, rivers, &c.; consequently, the original method of formation may be looked upon as that which produced the stock, constituted under strong and powerful influences, while the latter is destined merely to keep it up by atmospheric agency.

With respect to the material itself, the *hundred and fourth* Theorem states, "*That, in order to form a just idea of soil—which consists of small stones and sand, impalpable earthy matter, decaying animal and vegetable substances, and small quantities of salts—it is necessary to conceive different rocks to be decomposed and ground to fineness, some of their soluble parts dissolved in water, and that water adhering to the*

mass, and the whole mixed with the remains of vegetables and animals in different stages of decay, together with small portions of salts; the earthy matter, however, constituting their chief proportion. And that when the mineral ingredients of soils are traced to their ultimate elements, they are found to consist chiefly of silica, alumina, magnesia, and the oxides of iron and of manganese."

Bearing this information, and that which has been acquired in the previous chapters in mind, and applying both to the operations going forward on the *first* and *second* days of the Mosaic week, it will be acknowledged, that every requisite element was present for the production, in the shortest possible period, of a quantity of siliceous and calcareous materials, which, when joined to the *debris* spread abroad by the explosion of the protruded rocks, when they burst through the superincumbent strata, would be sufficient to form, by subsequent but almost immediate deposition, those unconformable suites which overlie the *coal measures*—the remains of the submarine vegetation of the primitive world—and also other portions of the original surface.

Therefore, in pursuance of the method hitherto observed, it is only now requisite to enquire whether geologists recognise any formations, whatever be their denomination, which correspond in character to the material here supposed to have been spread abroad. If we set aside, for the present, the limitations imposed by the nomenclatures of the various geological systems, and take a comprehensive view of the mineralogical and geological characteristics of these formations themselves, there will be discovered, with peculiar satisfaction, in the proofs which geology affords, a striking corroboration of the opinions which have been expressed, so much so, indeed, that the substance of the following evidence may be summed up in one brief sentence, namely, every formation superior to the carboniferous group and those of the same era affords evident symptoms of having been deposited from a heterogeneous mass of mineral *debris*, occasioned by some great and general catastrophe; while the coal series themselves, with the mountain limestone, and old red sandstone which underlie them, exhibit as evident symptoms of having together undergone some violent movement about the same period.

To prove this, I shall now commence a new series of enquiries, beginning with what is contained in the *thirty-first* Theorem, which states, "*That in the coal measures there is considerable persistency of character; those termed 'independent' being usually found in strata conformably to and overlying the mountain limestone and the old red sandstone; the whole three formations appearing to have been moved simultaneously, by the influence of great force, from where they were originally formed. That the magnesian limestone and new red sandstone, which usually overlie the coal measures, are, on the other hand, unconformable to them, and more horizontal in their position. That*

the lower portion of the new red sandstone series is generally formed of conglomerate and strata. And, finally, that there is a decided difference between the coal found in the independent formations, and the lignite or brown coal of the more recent deposits."

In support of these opinions Dr. M'Culloch expresses himself thus—

"The coal series which have been called independent, forms the great repository of that mineral in Britain, though not the exclusive one; and its leading character is to occupy a geological position superior to the old red sandstone, and inferior to the new one, or to the red marl. . . . . . As the beds of coal are found accompanying and alternating with stratified rocks, so they are also disposed in strata parallel to them. These strata are in every respect analogous, in their forms, dispositions, and accidents, to those of the rocks with which they occur. In position, they are horizontal, or inclined at various angles, often highly elevated, as in the whole series. . . . . . The thickness of a coal stratum varies, even from less than an inch, to ten or twelve feet, but it rarely exceeds two or three, and is, more often, much less; and thus particular strata become extenuated till they disappear. . . . .

"Now, it is essential to remark, that the old red sandstone, the mountain limestone, and the coal series, are all disturbed, being elevated, undulated, and fractured in various ways. . . . . . And it must, similarly, be recollected, that a new order commences with the magnesian limestone, and the red marl; or that they are placed on the coal series, and the inferior strata, in an unconformable position, while the lower substance also presents that conglomerate structure, which everywhere throughout nature accompanies a new order in rocks. Hence the first three deposits have often been united, as forming one class, and as if they had undergone but one disturbance common to the whole. But from the former remarks on this subject, it is plain that the coal series is really distinct, in time and production, from the inferior strata; and hence cannot be always truly conformable to them, though the last general disturbance is common to the whole."*

"It was not enough," observes Professor Buckland, when treating of the carboniferous series, "that these vegetable remains should have been transported from their native forests, and buried at the bottom of ancient lakes, and estuaries, and seas, and there converted into coal; it was further necessary that great and extensive changes of level should elevate, and convert into dry and habitable land, strata loaded with riches, that would for ever have remained useless, had they continued entirely submerged beneath the inaccessible depths wherein they were formed; and it required the exercise of some of the most powerful machinery in the dynamics of the terrestrial globe, to effect the changes that were requisite to render these elements of art and industry accessible to the labour and ingenuity of man.

"The place of the great coal formations, in relation to the other series of strata is shown in our first section; and they are represented as having partaken of the same elevatory movements which have raised the strata of all formations towards the mountain ridges, that separate one basin from another basin. . . . . .

* Geology, vol. ii. pp. 299—304.

"This disposition in the form of troughs or basins, which is common to all formations, has been more particularly demonstrated in the carboniferous series, because the valuable nature of the beds of coal often causes them to be wrought throughout their whole extent.

"One highly beneficial result of the basin-shaped disposition of the carboniferous strata has been to bring them all to the surface around the circumference of each basin, and to render them accessible by sinking mines in almost every part of their respective areas. An uninterrupted inclination in one direction only, would have soon plunged the lower strata to a depth inaccessible to man."*

"This valuable series of strata, the *carboniferous system*," says Professor Phillips, "to which Great Britain owes so much of her commercial prosperity, is extended irregularly over the basins of Europe, North America, Australia, &c. It occupies large breadths in Scotland, Ireland, England, and Wales, and lies in patches in various quarters of France, Germany, Poland, and Russia. Commonly it is found at the foot or on the flanks of primary mountains which had been previously uplifted, so that its stratification is not in accordance with theirs. . . . . .

"The variations in the development of the carboniferous system are considerable, and its occurrence is often in detached portions; it is, therefore, requisite for obtaining a general section, to combine the results of different and independent observers. . . . . . There are *three great formations* included in the carboniferous system, namely, firstly, *the upper formation, or coal measures;* three thousand feet thick in the North of England, consisting of abundance of sandstone and shales, layers of ironstone, and beds of coal. Of these there are many alternations, constituting a series of many nearly similar terms, usually containing at least the three substances, coal, sandstone, and shale. Scarcely any limestone occurs in this upper coal measure series. . . . . . The coal seams, twenty or thirty in number, amount in all to a thickness of about sixty feet, in a mass of shales and sandstones at least 3,000 feet; . . . . . And, secondly, *the mountain limestone formation,* which is best examined in the North of England. The whole series undergoing great changes, so as to afford northern and southern types applicable to all parts of the mountain limestone formation yet known in Europe."

This author, in continuation, classifies and briefly describes the rocks composing the several *terms* of these types, but the names merely are given here—

"'Millstone Grit,' 'Limestone Shale,' and the 'Limestone of Derbyshire,' compose the *Southern* type. The *Northern* type consists of 'Millstone Grit rocks, alternating with Shales,' 'Laminated Sandstones, Coal Seams, Ironstones, Chert Beds, and Limestones,' in various manners, according to the groups." . . . . .

And then follows the third or last of these divisions—

"*The old red sandstone formation,* varying in its character so as to offer little that is really of general application, except its colour and the absence of coal, and rarity of limestone." . . . . .

* Bridgewater Treatise, vol. i. pp. 525—527. In giving this extract I must be considered, of course, as differing in opinion with respect to the way in which Dr. B. considers the vegetable forms to have been heaped together. See the first part of the quotation.—AUTHOR.

"This varied series of rocks," Mr. Phillips goes on to say, "shows, in all its parts, the clearest proof of successive deposition; laminæ, beds, strata, whole rocks and groups of rocks are here seen to be generally parallel. It is, however, very true, that in each kind of rock the phenomena indicative of successive deposition are so far different as to admit of definition. . . . .

"After the deposition of this system, and before at least any considerable proportion of the superjacent rocks was formed, very extensive displacement happened in most parts of the surface of the globe where the carboniferous rocks have been deposited. . . . . Hardly a known coal tract being exempt from this influence, it would appear that convulsive movements took place of a very general description, so as to affect very large tracts of the surface of the globe. In the British islands, every coal district is disturbed and shaken in every square mile of its breadth by faults ('gauls, slips, troubles, and dykes'), passing in many directions, some of them having a great amount of 'throw,' and consequently affecting the working of the mines. But these minor effects lose their importance when we contemplate the gigantic disruption of Tynedale, the Penine chain, the Craven fault, the Derbyshire elevation, the fault of the vale of Clwydd, the double anticlinal axis of the coal fields of South Wales, and the parallel one of Namur. . . . . North of the Tynedale fault, is a depression or throw of 1,000 to 2,000 feet; west of the Penine fault, 2,000 to 3,000, or perhaps 4,000 feet under Crossfell; and south of the Craven fault 3,000 feet at least under Ingleborough."*

These interesting and appropriate evidences will be brought to a point by a short extract from Mr. Hugh Miller's work on the "*Old Red Sandstone*," assured that, together, these various quotations are quite conclusive with respect to the subject under immediate consideration:—

"The vegetable remains of the old red sandstone," he observes, "bear but a small proportion to its animal organisms; and from huge accumulations of these last decomposing amid the mud of a still sea, little disturbed by tempests or currents, and then suddenly interred by some widely-spread catastrophe, to ferment and consolidate under vast beds of sand and conglomerate, the bitumen seems to have been elaborated. These bituminous schists, largely charged with sulphuret of iron, ran far into the interior, along the flanks of the gigantic Ben Nevis, and through the valley of Strathpeffer. The higher hills which rise over the valley are formed mostly of the great conglomerates, but the bottom and the lower slopes of the valley are occupied by the bituminous and sulphurous schists of the fish bed, &c. . . . .

"Is it not a curious reflection that the commercial greatness of Britain in the present day, should be closely connected with the towering and thickly-spread forests of arboraceous ferns and gigantic reeds, vegetables of strange forms and uncouth names, which flourished and decayed on its surface, age after age, during the vastly extended term of the carboniferous period, ere the mountains were yet upheaved, and when there was as yet no man to till the ground?"†

After the perusal of these extracts, the mind may be considered

* Treatise, pp. 100—106, 112, 113.

† Old Red Sandstone, pp. 233, 234.

to be prepared for entering, with more effect, into the examination of the very interesting section of geological research comprising the several groups up to the chalk inclusive, which unconformably overlie the coal measures. This *latter* being considered by the Dynamical Theory to have been the last, or most recent deposit of the non-rotatory earth, it follows, that all those just mentioned, namely, the New Red Sandstone, the Oolitic, and the Cretaceous groups, are looked upon as having been formed by the *debris* spread abroad by the rotation of the earth around its axis. Before, however, entering upon the investigation of the new red sandstone group, it may be opportune to remind the reader of a former advertency, "that the explanation of the nature and origin of the saline deposits, so universally associated with this particular series, is reserved for a future part of this work; it being necessary to explain the formation of the atmosphere, and the manner in which the water was separated from the land, before these saline depositions can be satisfactorily accounted for."

The *thirty-second* Theorem states, "*That the formation called the* NEW RED SANDSTONE GROUP *is considered to be of mechanical origin and of heterogeneous composition; containing different kinds of fossil salts associated with gypsum, and much conglomerate and breccia.*

"*That conjointly with the Oolitic group, it frequently contributes to form extended tracts of level land, having aided in filling up immense hollows on the earth's surface at a time when, or immediately after, this latter had undergone a great and widely-extended revolution in its physical form, and in the condition of its vegetable and animal life.*"

The following are a few of the evidences which may be given in support of these opinions—

"We now arrive," Dr. M'Culloch says, "at the magnesian limestone of the English series, supposed to correspond to the first floetz stratum, to the Alpine limestone, and to the zechstein of foreign geologists, and followed by the later red sandstone, or red marl, agreeing with their variegated sandstone. A new order of arrangement here begins to be observed among the strata, whence we may take a fresh departure. It is not meant to say, that the red marl, much less the associated inferior limestone, is invariably present, even in Europe where it is known to occur; but if there is any series truly entitled to the character of regularity, as well as universality, using that term in the general sense formerly stated, it is this one. Still, it is proper to remark, that in the red marl series, which is in itself a very complicated one, there is a very irregular recurrence of the different integrant beds."*

And again—

"It is not always possible to distinguish the three red sandstones, except by careful geological investigations, since the mineral distinctions give but little assistance; the alternation of the primary sandstone with gneiss, or other primary strata, is an infallible geological criterion for that rock. With

* Geology, vol. i. pp. 274, 275.

respect to the red marl, the presence of salt is equally infallible; that of gypsum is a good test, if not absolute. Its superiority to the coal series is another, as is its immediate inferiority to the lias limestone. . . . . . The sandstone under review appears to be one of the most generally diffused rocks in nature; and may thus be considered like gneiss, among the deposits commonly called universal. . . . . . But that which distinguishes this deposit (upper sandstones) from all the secondary sandstones, is the presence of rock salt. . . . . . It is the proper, or even exclusive repository of salt, although the mineral occasionally passes beyond the rigid boundaries, on both sides, so as to appear in the magnesian limestone below it, and in the lias above."*

"These dissimilar conditions of three great divisions of our country," says Professor Buckland, "result from differences in the geological structure of the districts through which our three travellers have been conducted. The first will have seen only those north-western portions of Britain, that are composed of rocks belonging to the primary and transition series; the second will have traversed those fertile portions of the new red sandstone formation which are made up of the detritus of more ancient rocks, and have beneath, and near them, inestimable treasures of mineral coal."†

A little further on he observes in a note—

"Although the most frequent position of rock salt, and of salt springs, is in the strata of the new red sandstone formation, which has consequently been designated by geologists as the saliferous system, yet it is not exclusively confined to them. The salt mines of Wieliezka and Silecia are in tertiary formations; those of Cardona in the cretaceous; some of those in the Tyrol in the oolites; and near Durham are salt springs in the coal formations."‡

Professor Phillips states that—

"Even as early as 1791, Mr. Smith found proof of the faults in the coal strata of Gloucestershire and Somersetshire being anterior to the *new red marl*, for the horizontal beds of that formation lie level over the inclined and broken planes of the coal system."

And after going into many interesting details respecting the *new red sandstone system*, some of which have been quoted already, and others are reserved until we come to treat of the *saliferous* deposits associated with these rocks, he says—

"Upon the whole, then, this new red sandstone system is a vast mass of sandy and argillaceous sediments of a peculiar aspect, accompanied more than any others yet known by salt and gypsum, generally deficient in organic remains, and only locally enclosing strata of limestone, which commonly are characterized by abundance of magnesia. . . . . . Metallic veins are, in England, very rarely heard of in these rocks, and nowhere worked. . . . . .

"Several reasons might be adduced to justify an opinion, that the time occupied in the production of the whole system was comparatively short, such as the general uniformity of its composition, the deficiency (except in limited regions) of limestone; the peculiar chemical and mineral character

* Geology, vol. ii. pp. 214, 228. † Bridgewater Treatise, vol. i. p. 3.
‡ Bridgewater Treatise, vol. i. p. 71.

of these limestones; the general paucity of organic remains; the frequency of conglomerates and local admixture of fragments of igneous rocks—all these circumstances seem to indicate the predominance of an unusual series of agencies." . . . . .

Again, respecting the *oolitic* group, he says—

"The general result of all this is, that the type of the oolitic system of the South of Europe is more calcareous; that of the North of Europe more arenaceo-argillaceous. The former has the air of an oceanic, or deep sea deposit, little disturbed by currents of water; the latter was accumulated under the predominant influence of littoral agitation. In most cases the specially argillaceous formation is distinguishable from the specially calcareous upper oolites; the middle part of the system is the most variable, and the uppermost formation is merely local. . . . . .

"The deposition of the oolitic system seems to have followed upon that of the red sandstone rocks without the intervention of more than local disturbances; and it appears that few such disturbances broke the long uniformity of the periodical agencies exerted in the oolitic period. M. Murchison has shown that the elevation of the granitic mass of the Ord of Caithness, took place after the deposition of most of the oolitic rocks, for these are thrown into great confusion in the vicinity."*

We have a similar conclusion, though in a more descriptive style, from the pen of Mr. Miller, when delineating the characteristic scenery of the several formations:—

"Still the traveller passes on," says he, "the mountains sink into low swellings; long rectilinear ridges run out towards the distant sea and terminate in bluff precipitous headlands. The valleys, soft and pastoral, widen into plains, or incline in long-drawn slopes of gentlest declivity. The streams, hitherto so headlong and broken, linger beside their banks, and then widen into friths and estuaries. The deep soil is covered by a thick mantle of vegetation—by forest trees of largest growth, and rich fields of corn; and the solitude of the mountains has given place to a busy population. He has left behind him the primary regions, and entered on one of the secondary districts.

"And these less rugged formations have also their respective styles—marred and obliterated often by the plutonic agency, which imparts to them in some instances its own character, and in some an intermediate one, but in general distinctly marked and easily recognized. The chalk presents its long inland lines of apparent coast, that send out their rounded headlands, cape beyond cape, into the wooded or corn-covered plains below. Here and there, there juts up at the base of the escarpment a white obelisk-like stack; here and there, there opens into the interior a narrow grassy bay, in which noble beeches have cast anchor. There are valleys without streams; and the landscape atop is a scene of arid and uneven downs, that seem to rise and fall like the sea after a storm. We pass on to the oolite: the slopes are more gentle, the lines of rising ground less continuous and less coast-like; the valleys have their rivulets, and the undulating surface is covered by a richer vegetation. We enter on a district of new red sandstone. Deep narrow ravines intersect elevated platforms. There are

* Treatise, pp. 123, 127—129, 134, 135, 140.

lines of low precipices so perpendicular and so red that they seem as if walled over with new brick; and here and there, amid the speckled and mouldering sandstones that gather no covering of lichen, there stands up a huge altar-like mass of lime, mossy and grey, as if it represented a remoter antiquity than the rocks around."*

"The *Red Sandstone Group*," according to M. de la Beche, "is often one of very considerable thickness, and succeeds, in the descending order, the oolitic series previously noticed. . . . . .

"The rocks composing the red sandstone group occur in the following descending order:—1, variegated marl; 2, muschelkalk; 3, red or variegated sandstones; 4, zechstein; and, 5, red conglomerate, or todtliegendes. . . . . .

"Taken as a mass, the group may be considered as a deposit of conglomerate, sandstone, and marl, in which limestones occasionally appear in certain terms of the series. . . . . . The conglomerates, or todtliegendes, commonly occupy the lowest position; the sandstones form the central part, and the marls occur in the highest place.

"When we look for the causes which have produced this mass, we may, perhaps, in some measure approach them, by observing the state of the rocks on which it rests. These are found in the greater number of instances highly inclined, contorted, or fractured; evidences of disturbance which the inferior and older rocks have suffered previous to the deposit of the red sandstone group upon them. From an examination of the lower beds, no doubt can exist that the fragments of rock contained in them have, for the greater part, been broken off from the older rocks of the more immediate neighbourhood.

"It therefore does not appear unphilosophical to conclude, that, as far at least as regards these lower conglomerate beds, we have approached to something like cause and effect; the cause being the disruption of the strata, the effect being the dispersion of fragments, consequent on this violence, over greater or less spaces by means of water, probably thrown into agitation by the same disturbing forces.

"That these forces have, in some places, at least, not been small, is attested by the large size of the fragments driven off, and the rounded condition of some of them. . . . . .

"As we can scarcely conceive such a general and simultaneous movement in the inferior strata, immediately preceding the first deposits of the red sandstone series, that every point on which it reposes was convulsed and threw off fragments of rocks at the same moment, we should rather look to certain foci of disturbance for the dispersion of fragments, or the sudden elevation of lines of strata, sometimes, perhaps, producing lines of mountains, in accordance with the views of M. Elie de Beaumont. The accumulation of the larger fragments, and the relative amount of conglomerate, would, under this hypothesis, be greatest nearest to the disturbing cause; and amid such turmoil we might anticipate the occurrence of igneous rocks thrown up at the same period. . . . . .

"But we must now turn from this scene of disturbance, which may be one of the extreme cases, though many analogous facts might be adduced, to that state of things where no violent disrupting cause is to be surmised; but where, on the contrary, the cause which produced the arenaceous rocks that

* Old Red Sandstone, pp. 243, 244.

constitute the upper portion of the next and inferior groups, have not been interrupted by any sudden violence, one series of rocks passing into the other, so that the exact lines of demarcation are imaginary. Such a state of things is perfectly consistent with local and violent disturbances. . . . .

"Between such extremes there would be every variety of deposit produced either by difference in the intensity of the disturbing forces, or by local circumstances.

"After the causes, whatever they were, which produced the conglomerates and sandstones known by the name of *todtliegendes* had, in some measure, been modified, a considerable deposit of carbonate of lime, often charged with carbonate of magnesia, took place over certain parts of Europe. . . . .

"Viewed in the mass, circumstances appear to have been unfavourable in those parts of Europe which have been best examined, if not to the existence of animal and vegetable life, at least to their envelopment and preservation; for, with the exception of Alsace and Lorraine, few or no organic remains have been detected in it." . . . .

And in conclusion on this important subject from this author—

"If we now abstract our attention from these divisions, and regard the group as a mass, it would seem to constitute the base of a great system of rocks, which, when not deranged by local accidents, has filled numerous hollows and inequalities of land over considerable parts of the world; and seems, with the oolitic group, to fill up great depressions in Europe, sometimes, as is the case in Normandy, the oolitic rocks overlapping and covering and coming in contact with strata older than the red sandstone group, upon which latter they, nevertheless, rest so conformably, that the one seems a tranquil deposit on the other. We must, of course, consider that numerous local disturbances would produce a marked difference in the deposits, even amounting to a perfectly unconformable position, yet the conformable nature of the two groups, taken in the mass, is somewhat striking. During their deposit great and remarkable changes were effected in animal and perhaps vegetable life.

"It would appear, more particularly from the descriptions of Humboldt, that very extensive tracts of red sandstone and conglomerate exist in Mexico and South America. . . . . A series of red sandstones, intermixed with conglomerates, occur extensively in Jamaica. . . . . The mere mineralogical resemblance of the deposit, in America and Jamaica, with the sandstones and conglomerates of the red sandstone group of Europe, is, in itself, of no great value; and therefore we can only at present conclude, that considerable forces have been exerted in both parts of the world, whether contemporaneous or not remains to be determined, which have dispersed fragments of pre-existing rocks, scattering them, most probably, by the medium of water violently agitated, in various directions, the transporting powers being unequal, so that sandstones and marls alternate with conglomerates. These sandstones and conglomerates would appear, from the descriptions of geologists and intelligent travellers, to extend from Mexico far into the heart of North America; so that, if different deposits have not been confounded under one head, these sandstones and conglomerates of America would appear, not the result of a limited disturbance, but of one common to a considerable surface."*

* Manual, pp. 390, 400, 403—405, 408—412.

Mr. Lyell, in accounting for the *origin of the new red sandstone group*, says—

"The red sandstone, and red marl, which in point of thickness form the most considerable part, both of the upper and lower new red formation in England and Germany, may have arisen in great part from the disintegration of various crystaline or metamorphic schists; and sometimes, as in parts of Saxony and Devonshire, from porphyritic trap rocks, containing much oxide of iron. . . . . . The pebbles of gneiss in the tertiary red sandstone of Auvergne, point clearly to the rocks from which it has been derived. The red colouring matter may have been furnished by the decomposition of hornblend or mica, which contain oxide of iron in a large quantity.

"It is a general fact, and one not yet accounted for, that scarcely any fossil remains are preserved in stratified rocks in which this oxide of iron abounds; and when we find fossils in the new or old red sandstone in England, it is in the grey, and usually in the calcareous beds that they occur."*

This brings us briefly to consider the last two geological groups of continuous formation which are supposed by this theory to have been deposited from the *debris* of the world's rocky crust when it was first put into rotatory motion: and which materially assisted to fill up the hollows occasioned by the elevation of its mountain chains. They are referred to in the *thirty-third* Theorem, which states, "*That whatever may have been the nature and extent of the revolution, alluded to in the preceding Theorem, as having affected the earth's surface, it and its attendant circumstances seem to have exercised a direct and material influence over the widely-extended deposits, the 'Oolitic' and the 'Cretaceous Groups.' The Chalk formation being considered the most recent of the secondary series; after whose deposition there appears to have taken place a manifest change in the state and condition of our planet, and also in its vegetable and animal existences.*"

The evidences supporting these opinions are the following:—

M. de la Beche, when treating of the classification of rocks, has the following, which may be considered as a "*boundary*" passage:—

"Subsequently, from observations made by MM. Cuvier and Brongniart, on the country around Paris, a fourth class was instituted, and called tertiary, *because the strata composing it occurred above the chalk, a rock considered as the highest of the secondary class.*"

And when describing the cretaceous formation, he says—

"The upper portion of the cretaceous group partakes of a common character throughout a large portion of Western Europe, generally presenting itself under the well known form of chalk. . . . . . The white chalk, when freed from the flints or siliceous grains mixed with it, is found to be a nearly pure carbonate of lime; containing in 100 parts, carbonate of lime 98, magnesia and a little iron 1, and alumina 1. . . . . . Without entering further into the smaller divisions of the cretaceous group, it may be remarked, that the whole, taken as a mass, may, in England, and over a

* Elements, vol. ii. pp. 102, 103.

considerable portion of France and Germany, be considered as cretaceous in its upper part, and arenaceous and argillaceous in its lower part. . . . . . This group is extensively distributed over Europe. . . . . .

"Having premised thus much respecting the geographical distribution of the cretaceous group, we will give a slight sketch of the variations in its mineralogical character. Throughout the British Islands, a large part of France, many parts of Germany, in Poland, Sweden, and in various parts of Russia, there would appear to have been certain causes in operation, at a given period, which produced nearly, or very nearly, the same effects. The variation in the lower portion of the deposit seems merely to consist in the absence or presence of a greater or less abundance of clays or sands, substances which we may consider as produced by the destruction of previously existing land, and as deposited from water which *held such detritus in suspension*. The unequal deposit of the two kinds of matter would be in accordance with such a supposition. But when we turn to the higher part of the group, into which the lower portion graduates, the theory of mere transport appears opposed to the phenomena observed, which seem rather to have been produced by deposition from a *chemical* solution of carbonate of lime and silex, covering a considerable area. . . . . . No springs or set of springs, which we can imagine, are likely to have produced this great deposit of chalk, so uniform over a large surface. But although springs, in our acceptation of the term, could scarcely have caused the effect required, we may, perhaps, look to a greater exertion of the power which now produces thermal waters, for a possible explanation of the observed phenomena, ... the deposits arising from which have overlapped a great variety of pre-existing rocks, from the gneiss of Sweden to the Wealden deposits of south-eastern England inclusive. . . . . .

"M. Elie de Beaumont endeavours to show, that violent disruptions of strata in different situations, have preceded the deposit of the cretaceous group; and he infers this from the tranquil position of deposits of this nature on the upheaved beds of more ancient rocks. . . . . . Supposing this theory probable, we might ask, how far it would assist us in explaining the chemical character of the white chalk and flints, &c."

And further on he observes, with respect to the *Wealden rocks*—

"Some cause, with which as yet we are imperfectly acquainted, subsequently produced a great change in the relative levels of sea and land, and the cretaceous rocks, chalk, and green sand became deposited over a very considerable area, one apparently extending over a much larger superfices than that in which the last formed rocks of the oolitic series were deposited."

And lastly from M. de la Beche—

"The student will have collected from the foregoing pages, as indeed is also remarked by Professor Sedgwick, that there was in Europe, no important change in the general zoological character of deposits up to the Zechstein inclusive; the first great alteration, as far as we can at present see our way, being observed in the remains entombed in the variegated sandstones (gres bigarré), and muschelkalk."*

Mr. Lyell thus expresses himself regarding the *origin of white chalk*:—

* Manual, pp. 33, 259—267, 310, 520.

"Having, then, come to the conclusion, that the chalk was formed in an open sea of some depth; we may next enquire, in what manner so large a quantity of this peculiar white substance could have accumulated over an area many hundred miles in diameter, and some of the extreme points of which are distant, as we shall see in the sequel, more than 1,000 geographical miles from each other. . . . . . It had been often suspected, before these discoveries, that white chalk might be of animal origin, even where every trace of organic structure has vanished. . . . . . But this bold idea seemed to many naturalists a vague and visionary conjecture, until its probability was strengthened by new evidence brought to light by modern geologists.

"We learn from Lieut. Nelson, that, in the Bermuda Islands, there are several basins or lagoons almost surrounded and enclosed by reefs of coral. At the bottom of these lagoons a soft white calcareous mud is formed by the decomposition of *eschara, flustra, cellapora,* and other corallines. This mud, when dried, is undistinguishable from common white earthy chalk. About the same time Mr. C. Darwin observed similar facts in the coral islands of the Pacific; and came also to the opinion, that much of the white soft mud found at the bottom of the sea, near coral reefs, has passed through the bodies of worms and intestines of fishes; certain gregarious fishes of the genus *sparus* being visible through the clear water, browsing quietly in great numbers, or living like grazing herds of gramniverous quadrupeds. On opening their intestines they were found to be filled with impure chalk. This circumstance is the more in point, when we recollect how the fossilist was formerly puzzled by meeting in chalk, with certain bodies, called *cones of the larch,* which were afterwards recognized by Dr. Buckland to be the excrement of fish. . . . . .

"The area over which the white chalk preserves a nearly homogeneous aspect, is so great, that geologists have often despaired of finding any analogous deposit of recent date; for chalk is met with in a north-west and south-east direction, from the north of Ireland to the Crimea, a distance of about 1,140 geographical miles, and in an opposite direction it extends from the South of Sweden to the South of Bourdeaux, a distance of about 840 miles. But we must not conclude that it was ever uniformly spread out over the whole of this vast space, but merely that there were patches of it, of various sizes, throughout this area.

Now, if we turn to those regions of the Pacific over which coral reefs are scattered, we find some archipelagos of lagoon island, such as that of Dangerous Archipelago, for instance, and that of Radack, and some adjoining groups, which are from 1,100 to 1,200 miles in length, and 300 to 400 miles broad; and the space to which Capt. Flinders proposed to give the name of Corallian Sea, is still longer; for it is bounded on the west by the Australian barrier, on the east by the New Caledonian, and on the north by the reefs of the Louisiade. Although the islands in these spaces may be thinly sown, the mud of the decomposing zoophytes may be scattered far and wide by the oceanic currents." . . . . .

And when accounting for the *Greensand formation,* he says—

"Unlike the white chalk, this deposit consists of a succession of ordinary beds of sand, clay, marl, and impure limestone, the materials of which might result from the wearing down of the pre-existing rocks." . . . . .

With respect to the geological position of the chalk, this same author, in a previous part of his work, thus expresses himself:—

"We come now to the consideration of a class of fossiliferous formations, called 'tertiary' which are immediately antecedent in the order of time to the post-pliocene deposits already treated of. The name of tertiary has been given to them, because they are posterior in date to the rocks termed 'secondary,' of which the chalk constitutes the newest group."

In the sequel of "The Elements of Geology," Mr. Lyell enters into a detailed explanation of the manner in which it is considered that the chalk and its associated formations—firestone, gault, lower greensand, Weald clay, and Hastings sands, were brought into their present position in the Weald district, by the powerful denuding action of water, during the period of their being upheaved; and he calls in the aid of his distinguished contemporary labourers, Messrs. Mantell and Martin, to confirm these opinions; while he appeals for their corroboration to Mr. Hopkins's mathematical investigations. Unfortunately, these passages, which contain so much detail, are too long to admit of being inserted here, and, therefore, Mr. Lyell's work itself must be referred to.*

Professor Phillips observes—

"It is found by actual observation, that the chalk, which is the lowest mass of strata noticed in the vicinity of London, is continuous with and forms part of that chalk which is at the top of the Oxfordshire series. It is also found that this same chalk is actually traceable, with little interruption, in a very clear and satisfactory manner, from Oxfordshire into Yorkshire, where also it forms the top of the section; that the oolitic rocks, the blue clays and limestones, the red clays and red sandstones, are in the same way continued from Oxfordshire to Yorkshire. The same stratified rocks then occur in very distant situations in the same order of succession, having certain rocks above them. If, now, we compare the Cambrian and Scottish series of rocks, we shall find several common terms in similar parts of the series, and thus be able to unite all the five sets of observations into one general view.

"The continuity of the strata near to the surface of the earth, and the constancy of their order of succession, being thus shown to be susceptible of exact proof, they are unequivocally established." . . . . .

And again—

"The cretaceous system is unconformed to the oolites at only two points in England, viz.—in Yorkshire and Derbyshire; and round the basin of Paris and in the south of France the same conformity of the two systems is found to prevail. It thus becomes easy to trace the boundary of the cretaceous rocks by referring to the outline of the oolites. The chalk and its associated beds pass from Yorkshire through Lincolnshire, Norfolk, Suffolk, Hertfordshire, Bedfordshire, Buckinghamshire, Oxfordshire, Wiltshire, to Dorsetshire, always presenting a noble front of rounded hills to the west and north-west. Thence they return to the east through the Isle of Purbeck and the Isle of Wight, the broad inland surfaces, which are included be-

* Vol. i. pp. 391—404, et seq., and vol. ii. pp. 2—38.

tween the Isle of Wight and the Hertfordshire hills being formed into two parallel synclinal troughs, the vales of London and of Hampshire, separated by one great anticlinal axis, passing from Wiltshire to the coast of Kent, and continued into France in the district of Boulogne. The anticlinal axis alluded to changes through Sussex into a great denudation, or valley of elevation, exposing the Wealden formation in the centre, with escarpments of the cretaceous system on the north, south, and west in England, and on the east in France. Hence, in general terms, we may say the chalk of England is distinctly related in escarpments and slopes to the present German Ocean, and the eastern part of the English Channel. . . . . .

"In France, the cretaceous system, commencing at Calais, sweeps in a vast circle round Paris by Lille, Chalons, Troyes, Saumur, and Le Mans, to the embouchure of the Seine; thus appearing as a great southward branch of the English chalk system, formed in a bay of the then ocean, which was defined between the mountains of Brittany, La Vendeé, Auvergne, the French Jura, and the Ardennes. From this great area (principally chalk) a broad expanded but mostly subterranean mass of cretaceous strata extends along the north side of the Ardennes and the valley of the Meuse, and continues along the northern border of high ground in Germany, from Essen to Paderborn, turning as that border turns to Osnaburg, and then returning through Hanover and Brunswick. It reappears along the range of the great tertiary plains which stretch to the north into Russia, and to the east to the Black Sea. In Denmark and Scania and along the Baltic (Isle of Rugen) chalk occurs in its usual character. Along the northern and southern flanks of the Alps some beds of the cretaceous system range extensively. Along the Pyrenees, the chalk system is very fully developed, and has been uplifted to great elevations by disturbances of comparatively recent date. In the south of Spain also chalk with flint occurs. In America rocks of the cretaceous period are abundant along the eastern side of the United States, particularly in New Jersey, along the coast of the Carolinas, in Georgia, Florida, and Alabama, true chalk, however, being wholly unknown, or at least very rare. . . . . .

"The most characteristic deposit, as along the Alps, being greensand, associated with limestones, compared to oolites in New Jersey, having a more chalky aspect in Florida and Alabama, where it assumes important features, but without real chalk or true flints."

And in conclusion, from Professor Phillips—

"It is rendered evident that the English type is more or less applicable to the greater portions of the earth's surface where the cretaceous system has been recognised; that the lower parts of the system are generally sandy, the upper parts often calcareous, but that the development of those two groups is not proportional nor depending on the same centres of influence. In the north of Europe the upper group seems generally to predominate, but in the middle of Europe the greensand system is more expanded and regular; in the northern parts of the United States the greensand abounds, in the southern calcareous rocks are more important. Yet upon the whole it must be granted, that the agencies concerned in producing the cretaceous system were more extensive and uniform than those by which the oolites were accumulated.

"Two formations are almost universally admitted as constituting the cretaceous system.

"*The chalk formation*, named from the most characteristic mineral substance; thickness 600 feet. It includes the following groups: Maestricht beds, upper or flinty chalk, middle or hard chalk, lower chalk or chalk marl.

"*The greensand formation*, commonly abounding in a green silicate of iron; thickness 600 feet. It includes upper greensand, &c., golt or blue marly clay, lower green or iron sand, with beds of sandy or chalky limestone. . . . . .

"The tertiary strata have, in general, to the chalk the same geographical relations as that to the oolites. Throughout England the chalk is the base of all the tertiary strata. In France this is generally the case, and almost universally so for the marine tertiaries. In the North of Germany, along the north and south slopes of the Alps, and in the basin of the Danube, this is at least very extensively true. In North America the general basis of the tertiaries is the cretaceous formation. On more close enquiry, it appears, however, that the tertiary strata are seldom exactly conformed to the stratification of the chalk; that anything like a gradation or alternation of the cretaceous into tertiary deposits is rarely known; that the organic remains of the one group differ almost wholly and absolutely, except in the South of France, at Maestricht, &c., and constitute two distinct groups of created life. Hence it has become a popular opinion, that with the secondary strata ended a certain general condition of the globe, and with the tertiaries commenced a totally new arrangement. Moreover, because we find the marine tertiary strata distinctly related, in geographical expansion, to the present basins and arms of the ocean; as the organic remains which they contain are similar, and, in rocks of later date, identical to those of the existing races in the sea and on the land; and as the tertiary sediments are of a nature very analogous to the daily products of the sea, estuaries, tide-rivers, and lakes, there is but a step further to unite the tertiary era with the historical period of the globe, and to place the commencement of the actual creation or arrangement of organic nature at the epoch immediately following the chalk."*

As final evidence on this particular point, I give the following quotation from Mr. Ansted's work:—

"Over a large part of the known world, the close of the first epoch, marked by great subsidences of land, by the swallowing up of continents and islands into the sea, and by accompanying violent dislocations of the stratified crust of the globe, was of necessity accompanied by the re-distribution of these fractured materials of strata; and owing, no doubt, to the great amount of trituration, the beds thus formed contain but few remains of organic beings. These, however, indicate the commencement of the new era. The presence of the new red sandstone, a formation consisting of sand and marl, with rare local interpolations of limestone, characterises this epoch; and, after this, until towards the close of the secondary or middle period, we find few intermediate beds over the whole of America; and the same is the case with regard to the greater part of Asia and Australia, as far as geologists have yet been able to determine. . . . . .

"The deposit of sand and marly beds, which must have been steadily continued for a long time over extensive tracts at the commencement of the

* Treatise on Geology, pp. 33, 149, 153, 161, 162.

secondary period, seems to have gradually changed to a finer, more calcareous, and less sandy mud thrown down from suspension in water, perhaps after it had been carried for some distance by marine currents. . . . . .

"After the termination of that great deposit of calcareous mud, so characteristic of the older part of the middle secondary period, considerable change seems to have taken place in the relative position of land and sea; and, from the abundance of calcareous rock afterwards developed, as well as from the nature of the fossils, it may safely be concluded that these changes involve important alterations in the whole system of organic nature in this part of the world. And we may venture to conclude, that, immediately after the deposit of the lias, the bed of the sea was affected by widely acting earthquake movements, and that tracts of land, more or less extensive, rose up, especially on the north-eastern flank of the lias in Yorkshire, in several districts on the continent of Europe, and in the central and eastern portions of North America.

And again, further on, he continues—

"The close of the secondary period was succeeded by a general disruption of the various beds that have been deposited in those parts of the earth to which we now have access, and by changes and modifications so considerable as to alter the whole face of nature. It would appear, also, that a long period of time elapsed before newer beds were thrown down, since the chalky mud not only had time to harden into chalk, but the surface of the chalk itself was much rubbed and worn. So completely and absolutely is the line of demarcation drawn between the secondary and newer deposits, in parts of the world where these beds have been recognized in actual contact, that it had become a common notion amongst geologists, to assume the destruction of all natural relations between them, concluding that not one single species of animal or vegetable connected the two periods, and lived through the intervening disturbances. Although this view certainly requires modification in points of detail, it is still correct in a general sense, and expresses, without much exaggeration, the real extent of difference in condition, the result, perhaps, a lapse of time greater than is elsewhere indicated. In this way the secondary period is distinctly cut off from the tertiary. It is scarcely less separated by the fact, that in the former we everywhere find marks of the presence or near vicinity of the sea in all the deposits, even those from fresh water, while, in the newer beds, land animals at once assume the importance which they have ever since retained, having been evidently present in great numbers and variety. . . . . . We have to enter upon a new series of phenomena, when we turn from the contemplation of the secondary to that of the tertiary period. When, however, the time had elapsed, and the change had taken place, and it must be repeated, that the interval, whether long or comparatively short, was marked by the destruction of nearly the whole marine creation; when, after this, the sea bottom in these parts of the world again received accumulations of mud and shingle, it is not unlikely that a great elevatory movement had already commenced. From the general direction of the subsequent disturbances which brought to light the Wealden district in England, and elevated the Alps and the Caucasus, it is almost certain that the line of that movement was, on the whole, east and west."*

* Ancient World, pp. 115, 135, 183, 265, 266.

According to the order in which geological phenomena are usually classed, it is now necessary to take a hasty view of an interesting suite of formations; which, from some peculiarities, in the manner of their collocation, have been styled *tertiary*, in contradistinction to the *primary* and *secondary* divisions. They are situated in detached groups surrounded by the other two classes, without appearing to have been affected by them, although, in many instances, they are indebted to them for the basins in which they exist; while symptoms of having been deposited from a mass of finely comminuted material are amply afforded.

The sudden manner in which it is considered, by this theory, that the primeval water, which bore the mass of debris, was separated from the dry land, by *vaporization*, prevents the whole of the tertiary suite being acknowledged as the result of the commotion which took place amongst the rocky masses, and of the rush of water from the polar towards the equatorial regions, occasioned by the earth's first rotation. On the contrary, these principles constrain us to look to another and more recent cause for the origin *of the newer or upper portion* of those tertiary deposits; feeling confident, that a closer examination will reveal, in the very formations themselves, a well marked boundary line between the phenomena originating from the first rotation of the earth around its axis, and those which accompanied a much later and less auspicious event. It is presumed, that in the circumstances attending the subsiding of the water of the Noachean deluge there may be found an adequate explanation of the formation of the *upper* part of the tertiary strata. However tranquilly and slowly it may have risen to overwhelm its victims; and however slight may have been its effects upon the more prominent geological and geographical features of the world, there can be as little doubt, according to the testimony of Scripture,* that, when it began to assuage, it was kept, by the continual action of wind, in a state of agitation, for wise and provident purposes. This violent movement, while intended to accelerate vaporization, would, by causing comminution and the washing away of the softer soils, impregnate the water, as it subsided, with earthy sediment. This earthy sediment, evidently much more pulverised than the debris occasioned by the first rotation, would, on subsiding, entomb the accumulated remains of those creatures in whom had been the breath of life, when the living principle, with but little exception, was extinguished upon the face of the earth, and thereby rid its future inhabitants of the pestilence which so much putrid animal matter would, otherwise, have occasioned.

As it is intended, at a future period, to enter fully into this department of geological research, and to offer some explanations, I make this passing allusion only, and revert, for the present, to the more immediate argument; preparing the mind for what may follow

* Genesis, viii. 1.

by subjoining the Theorem and evidences referring to the tertiary strata; although I shall refrain from offering any remarks until the sequel of the treatise. Meanwhile, it is to be hoped that the care of defining, with precision, the boundary line which separates the formations due to dynamical causes, from those which resulted from the Noachean Cateclism, will occupy the attention of some zealous and unprejudiced advocate of the truth.

The object sought, in this part of the discourse, having been to account for the enormous mass of *mineral debris* which was scattered abroad, when the disruption of the strata took place, at the first rotation, by the bursting through of the subjacent rocks; and whose extent of surface, it may be remembered, was estimated on a moderate computation at *three millions seven hundred and fifteen thousand square miles;* some estimate of the mineral contents of this vast area may be formed, when it is considered that it has to be multiplied by the thickness of the accumulated strata of which it was composed! Did there exist no suites of formations reposing unconformably upon the older and elevated stratified masses; spreading themselves over widely-extended spaces, and filling up hollows on the earth's more recent geological outline, I should not have known where to have sought, or how to have accounted for the immense mass of mineral matter which this theory thus presupposes to have been disrupted and spread abroad at that particular juncture. The existence, however, of strictly corresponding formations, relieves me from all anxiety on this point, and fully confirms the theory. How they may be satisfactorily accounted for, with all their concomitant circumstances, independently of the Dynamical Theory, I am at a loss to conjecture, and must, therefore, leave it to others, should they think proper, to endeavour to give the required explanation.

The *eighteenth* Theorem, above alluded to, is to the following effect: "*That in contrasting the secondary with the tertiary formations, a marked difference is observable in many respects between them; the former being generally more continuous in their series, and more equal in mineralogical character than the latter, and especially than their more recent portions, which are found situated in detached basins surrounded by primary and secondary formations, in very many instances without either being deranged or altered by them.*"

Professor Buckland states that—

"The tertiary series introduces a system of new phenomena, presenting formations in which the animal and vegetable life approach gradually nearer to species of our epoch. The next striking feature of these formations consists in the repeated alternations of marine deposits with those of fresh water.

"We are indebted to Cuvier and Brongniart for the first detailed account of the nature and relations of a very important portion of the tertiary strata, in their inestimable history of the deposits above the chalk near Paris. For a short time, these were supposed to be peculiar to that neighbourhood;

further observation has discovered them to be parts of a great series of general formations, extending largely over the whole world, and affording evidences of at least four distinct periods, in their order of succession, indicated by changes in the nature of the organic remains that are imbedded in them. . . . . . M. Deshayes and Mr. Lyell have recently proposed a fourfold division, of the marine formations of the tertiary series, founded on the proportions which their fossil shells bear to marine shells of existing species. To these divisions Mr. Lyell has applied the terms eocene, miocene, older pliocene, and newer pliocene; and has most ably illustrated their history in the third volume of his 'Principles of Geology.'

"The term eocene implies the commencement or *dawn* of the existing state of the animal creation; the strata of this series containing a very small proportion of shells referable to living species. The calcaire gossier of Paris, and the London clay, are familiar examples of this older tertiary, or eocene formation.

"The term miocene, implies that a minority of the fossil shells in formations of this period, are of recent species. To this era we referred the fossil shells of Bourdeaux, Turin, and Vienna.

"In formations of the older and newer pliocene, taken together, the majority of the shells belong to living species; the recent species in the newer being much more abundant than in the older division."*

Professor Phillips says—

"Without in the least wishing to intimate, that the influence of fresh water in accumulating the materials of the strata is most conspicuous in the newer strata, an inference not justifiable by the facts, it is to be remarked, that the deposition of stratified rocks in limited basins of fresh water is a phenomenon almost characteristic of the tertiary period. . . . . .

"It is evident, from comparing the sections given, that no special resemblance of the strata in thickness or mineral composition can be traced, such as we have found to be frequently observable while examining the older strata. All are composed principally of calcareous, arenaceous, and argillaceous matter, but so are the secondary strata. We do not find in the different regions compared any settled order of succession among the rocks of different nature. The English series has no marine limestone; the Parisian no thick marine clays; the sub-Apennine deposits have little arenaceous matter. It is apparent, in fact, that the tertiary deposits vary as to their mineral composition, very much more in relation to locality than to geological time; a fact which at once subverts all hope of arranging them in geological chronology, by comparison of their mineral constitution. It also leads us to infer that the deposition of tertiary strata took place in arms and gulfs of the sea, which ramified among the masses of land then raised in Europe, and derived sediment of different nature from these different lands. Hence the sub-Alpine tertiaries have one character; those of the sub-Apennines another; the sub-Pyrenean a third; the Parisian a fourth; the English a fifth.

"By prosecuting this research, we find, in fact, that the tertiary formation was sometimes produced in insulated seas, like the Adriatic, and the valleys of the Rhine and Danube; at other times, under the influence of the general ocean, as those in the plains of the Garonne, often in basins like the Parisian series."†

* Bridgewater Treatise, vol. i. pp. 76—78.

† Phillips, pp. 163, 178.

M. de la Beche says—

"Prior to the labours of MM. Cuvier and Brongniart on the country round Paris, the various rocks comprised within the supra-cretaceous (tertiary) groups were geologically unknown, or were considered as mere superficial gravels, sands, or clays. Subsequent to the publication of their memoirs (1811), it has been found that the geological importance of these rocks is very considerable, and that they occupy a large part of the superfices of the present dry land, entombing a great variety of terrestrial fresh water and marine remains."

Regarding the organic remains, he observes—

"The present theory seems to be, that though certain shells may not be precisely peculiar to certain beds, they are more abundant in them than in others, and that the uniformity of organic contents is greater as we descend in the series of fossiliferous rocks; so that the older the beds the greater will be the uniformity over considerable spaces; and the newer the series, the less the uniformity."

In continuation, M. de la Beche says—

"Now, all the terrestrial animals found in caves and superficial gravels, marls, and sands, whatever may be the theory formed to account for their disappearance, must have lived upon lands existing at the period under consideration (the supra-cretaceous); and even supposing them in a great measure destroyed by a catastrophe, there is nothing to prevent their having been abundantly entombed during their residence on the earth. The nearer also, judging from organic remains, that the climates can be considered like those now existing, the greater would appear the probability that the rocks containing them occupied the higher part of the supra-cretaceous series."*

"If," says Mr. Lyell, "we take a handful of quartzose sand, mixed with mica, and throw it into a clear running stream, we see the material immediately sorted by the water, the grains of quartz falling almost directly to the bottom, while the plates of mica take a much longer time to reach it, and are carried farther down the stream. At the first instant the water is turbid, but immediately after the flat surfaces of the plates of mica are seen alone reflecting a silvery light, and they descend slowly, to form a distinct micaceous lamina. . . . . It is easy, therefore, to conceive how the intermittent action of waves, currents, and tides may sort the sediments brought down from the waste of a granitic country, and throw down the mica, layer after layer, separately from the mud or sand. . . . .

"Patches of 'tertiary,' strata," he continues, "some of fresh water, others of marine origin, have been observed in various parts of Europe, their geographical extent being usually small, as compared to the secondary formations, and their position often suggesting the idea of their having been deposited in different bays, lakes, estuaries, or inland seas, after a large portion of the European area had already been converted into dry land. They all agree in containing organic remains, which make upon the whole a nearer approach to the generic and specific types of the living creation, than to the fossils of the secondary rocks."

And further on, entering more into particulars, he says—

* Manual, pp. 192, 193, 199.

"The accompanying map," (to which reference is requested,) "will explain the position of the principal eocene formations (tertiary) of England, the Netherlands, and France. Those of England, it will be seen, are confined to two districts, usually called the basins of London and Hampshire. These tracts are bounded by rising grounds, composed of chalk, except where the sea intervenes. That the chalk passes beneath the tertiary strata as represented in Figure 163, p. 387, we not only infer from geological data, but can prove by numerous artificial sections at points where railways have been cut, wells sunk, or borings made through the overlying beds. . . .

"The area which has been called the Paris basin is about 180 miles in its greatest length from north-east to south-west, and about 90 miles from east to west. This space may be described as a depression in the chalk, which has been filled up by alternating groups of marine and fresh water strata." . . . . .

When treating of the *general arrangement and origin of the fresh water formations of Auvergne*, he exemplifies them by observing—

"We may easily conceive a similar series of events to give rise to analogous results in any modern basin, such as that of Lake Superior, for example, where numerous rivers and torrents are carrying down the detritus of a chain of mountains into the lake.

"The transported materials must be arranged according to their size and weight, the coarser near the shore, the finer at a greater distance from the land; but in the gravelly and sandy beds of Lake Superior no pebbles of modern volcanic rocks can be included, since there are none of these at present in the district. If igneous action should break out in that country, and produce lava, scoriæ, and thermal springs, the deposition of gravel, sand, and marl, might still continue as before; but, in addition, there would then be an intermixture of volcanic gravel and tuff, and of rocks precipitated from the waters of mineral springs." . . . . .

The following passage confirms what has been given, by a different line of proof, namely, organic remains:—

"The *Catillus* may be pointed out as a form which, so far as our present information extends, became extinct at the close of the cretaceous period, being never met with in any tertiary stratum, or in a living state. Among other equally conspicuous forms of fossil mollusca belonging to the cretaceous group, and foreign to the tertiary and recent periods, may be mentioned the *Belemnite*, *Ammonite*, *Baculite*, and *Turrilite*, of the family *Cephalapoda*, to which the living Cuttle-fish and Nautilus belong."*

"Of all the classes of aqueous deposits," observes Professor Phillips, "that which is the nearest to our own days in point of date is the least exact in its boundaries and characters. While, concerning the older periods, the problem of the condition of the globe was principally confined to considerations relating to the sea, and thus the phenomena could be investigated according to fixed principles, applicable to at least the greater number of strata; the tertiary deposits compel us to enter also upon more complicated researches connected with the land; and, in discussing the history of still later phenomena, all the variations of physical geography assume still higher degrees of importance. The consequence is an amount

* Lyell's Elements, vol. i. pp. 31, 32, 270, 336, 346, 377, 387.

of local diversity so great as to nearly annihilate all generality of result. Moreover, the difficulties of this subject are augmented by a circumstance which is likely to become daily more and more influential on geological reasoning:—the want of a principle upon which to define the limit of least antiquity of this group of strata. What, in fact, is meant by supra-tertiary deposits? If we substitute for this term modern aqueous products, do we understand it the better? or, attempting analysis, if we adopt as an equivalent expression the diluvial and alluvial accumulations, how are these to be defined? It is evident that here is a serious embarrassment. What is meant by tertiary strata? If we should venture to include in this title all really marine deposits posterior to the chalk, even such as were only yesterday raised from the bed of the sea, it would be more intelligible than the methods now followed by geologists. For with the tertiary strata of Europe begins that extreme *analogy* of the specific forms of organic life, that *identity* of generic conformation, which at once announces great and general differences of physical condition between them and the older strata, and equally great resemblances to the present order of things. Such results apply to marine, fresh water, and terrestrial life; and, as far as yet appears (but the evidence is very incomplete), nearly in an equal proportion to each." . . . .

He further observes—

"Assuming, for the moment, that the conclusion of the gradual change from the oldest tertiary to the actual phenomena produced in the interval from the date of the cretaceous deposits to the present era, may be ranked in one great system, like those adopted for earlier periods, where shall we place the point of union between the modern or historical, and the ancient or geological scales of time? In other words, to what part of the supra-cretaceous period shall we refer the creation of man? To this important question impartiality must allow, that geology gives no clear and certain answer. Geology has no evidence on the subject that is at all of a positive character. We believe that the older stratified rocks were preadamitic for four reasons; because no trace of man or his works have ever been seen in them; because no remains of animals and plants occur in them which can be considered the same, or very similar to the existing forms of life; because land quadrupeds generally are almost utterly unknown in them; because the physical conditions of the globe were entirely different from what we now behold. . . . . .

"It is evident," he goes on to say, "that all the probabilities point to the conclusion, that the creation of man, and all the new arrangements connected with that event, are to be placed in some part of the supra-cretaceous period; but in what part is to be determined by further and cautious research." . . . . .

And in conclusion, from Professor Phillips—

"As far as direct observation or satisfactory inference goes, every honest geologist will allow that he is ignorant of the point of union between the historical and geological scales of time; that the era of human existence, if recorded in geological monuments, has not yet been discovered among the small number which have been fully deciphered."*

Before closing the evidence for this particular branch of our

* Treatise on Geology, pp. 190—193.

subject, I take occasion to transcribe the dictum respecting it of one of the most scientific and indefatigable of our British geologists:—

"The grand fact of *an universal deluge,*" Dr. Buckland observes, "at no very remote period is proved on grounds so decisive and incontrovertible, that had we never heard of such an event from Scripture, or any other authority, geology, of itself, must have called in the assistance of some such catastrophe, to explain the phenomena of diluvial action which are universally presented to us; and which are unintelligible without recourse to a deluge exerting its ravages at a period not more ancient than that announced in the book of Genesis."*

On the same line of proof we have the following confirmatory evidence by Professor Henslow:—

"The history of vegetation could not be completed without some enquiry respecting those plants which existed on the earth in its primeval state, during the extended geological epochs which elapsed before the establishment of the present order of things. . . . . . It was soon remarked, when the study of fossil vegetables began to attract the attention of botanists, that those from the coal measures were distinct from the plants now existing on the surface of the earth; . . . . . that the species embedded in different strata likewise differ from each other; and that, on the whole, there are about fourteen distinct geological formations in which traces of vegetables occur. . . . . .

"Mons. Brongniart has grouped the several formations, in which vegetable remains are found, under four great epochs, during each of which no very marked transitions occur in the general character of the vegetation; but between any two of these epochs, a striking and decided change takes place; even most of the genera are different, and none of the species are alike. These epochs include the periods during which the following strata were deposited:—1st. 'From the earliest secondary rocks to the uppermost beds of the coal measures;' 2nd. 'The new red sandstone formation;' 3rd. 'From the lowest beds of the oolitic series to the chalk inclusive;' and 4th. 'The beds *above* the chalk.' . . . . . Speculations of this description, imperfect as they confessedly are at present, may one day lead to the most important results, and may teach us many truths, respecting the earliest condition of our planet which the science of astronomy could never have suggested. And surely no one ought to consider such enquiries too bold for our limited faculties, needless for our present, or dangerous for our future welfare. No naturalist, desirous of knowing the truth, can be so weak as to fancy that any search into the works of God, or any contemplation of the wonders of His creation, can interfere with the lessons He has taught us in His revealed and written word."†

Before departing from these, which may be termed THE MINERAL GROUPS OF EVIDENCE FOR THE TRUTH OF THE DYNAMICAL THEORY; and while alluding to the precision with which they point to the

* Vindiciæ Geologicæ, pp. 23, 24.

† Botany, in Cab. Cyc., pp. 310—314. Part of this quotation has been given already, but such repetitions are almost unavoidable; inasmuch as one passage, from any author, may, and not unfrequently does, afford evidence in favour of several distinct positions, each of which is sought to be established.

line of demarcation between those extensively persistent rocky deposits, occasioned by the general outbreaking and upheaving commotion of the first rotation, and the finely comminuted and more tranquilly deposited earthy and clayey formations of the upper tertiaries; I must not overlook the concurring testimony as to the isolated character of these latter, deduced alike from their *internal structure*, or *composition*, and from their *situations*. These facts, which are perfectly in accordance with disintegration, occasioned by water agitated by fierce winds, and consequently acting on each locality, without being attended by progressive motion, is wholly inconsistent with the violent rush of water which was occasioned by the protorotation of the earth. While the local comminution and deposition, which seem so strongly to be evidenced by the newer tertiary rocks; and which have drawn from so many geologists the concurring opinion, that they were formed in lakes and estuaries, at mouths of rivers, and from the detritus of surrounding hills and anterior formations—an opinion more strongly and truthfully expressed by Mr. Phillips than by any of his contemporaries—is satisfactorily corroborative of a system which disowns them as the result of an impetuous onward rush of water, speedily evaporated from the high lands and dry portions; while, on the other hand, it refers them to the more stationary, though not altogether tranquil subsidence of the waters of the deluge, when "a wind was made to pass over the earth, and the waters assuaged; the fountains also of the deep, and the windows of heaven, were stopped, and the rain from heaven was restrained; and the waters returned from off the earth continually: and after the end of the hundred and fifty days the waters were abated."*

* Genesis viii. 1—3.

SECTION V.

GEOLOGICAL PHENOMENA RESULTING FROM THE EARTH'S PROTOROTATION.

CHAPTER XXVII.

Erratic block group. The importance of travelled debris in substantiating the Dynamical Theory. Geologically described, and copious evidences given respecting them. The information acquired applied to the point under discussion, and to the assumed condition of the earth, at the period of the origin of the Erratic Block Group, and found to agree most conclusively.

THE attention is now to be directed to the last division of geological phenomena which are required to be noticed—a class whose elucidation, by means of this hypothesis, is almost of itself capable of proving its soundness. I allude to the *fragments* of rock, on which Sir Henry de la Beche has conferred the title of the "*Erratic Block Group,*" a designation which will be found to be most appropriate, when the true origin and history of the *debris*, of which it is composed, shall have been investigated by the light of the Dynamical Theory.

A learned geologist, having occasion to allude to some of the boulders of the north of England, said, "that many of them fortunately were land-marks, and boundary-stones of parishes, otherwise much of their curious history would have been lost under the hammer of the mason and of the road maker."* While gladly adopting, I would likewise extend this idea, and add, that fortunately, indeed, have they been preserved, from respect to those minor offices which they now fulfil; for they likewise perform the more important duty of pointing out to the world's inhabitants how this pedestal, on which they are wheeled through space, received its variety of hill and dale from the hands of their common Creator! In short, they are the "land-marks" of the Dynamical Theory, and exhibit, in language which can neither be misinterpreted nor denied, that the earth, when first caused to revolve around its axis, received the form, which, in its greater outlines, it still preserves.

But let the geological evidences be first adduced, and afterwards the appropriate inferences deduced from them. The *thirty-fourth*

* Professor Phillips, at the British Association, 1836.

Theorem has exclusive reference to these interesting fragments, and states—"*That in several parts of Europe and America, immense quantities of travelled debris, gravel, and massive boulders, termed by Sir H. de la Beche* "THE ERRATIC BLOCK GROUP," *are found either resting on or imbedded in the soil. That the boulders and larger debris, when they have been traced to the nearest fixed group of the same mineralogical character, are generally found to have come from a considerable distance. That those boulders in Britain, Germany, Russia, and North America, whose sites and derivations are ascertained, have been identified with mountain chains existing to the north of where they now lie; whilst those in South America seem, on the contrary, to have originated from localities southward of their present resting places. Finally, the position of the gravel and smaller detritus appears to have been materially modified by local formations.*"

The evidences on which this important theorem rests, being of an interesting character, will be given at considerable length:—

"There are," says Professor Phillips, "geologists who would gladly expunge the word diluvial from our nomenclature, and instead of appealing to one or several general convulsions for the explanation of some striking fact, are willing to believe that small and local forces, operating through long time, are sufficient for the purpose of geological speculation. But who will concur in the correctness of these views that has seen the enormous dislocations of the carboniferous system of South Wales, and the north of England? or has imagined to himself the upraising of a chain of mountains like the Alps, or witnessed the enormous conglomerates on their flanks? What, therefore, is to be done but to allow the alternative, namely, the occurrence of great and violent movements of large bodies of water, partial though not general deluges?"

"The erratic blocks," continues Prof. Phillips, "as the larger boulders are called, which have been transported from the Alps, are most remarkable on the eastern face of the Jura, which looks towards the Alps, over the vale of the Arve and the Lake of Geneva. On the Jura, 1,500 to 2,000 feet above the lake of Geneva, crowning the hills and filling the valleys and rocky glens, these blocks abound; and likewise opposite to the embouchures of these valleys, and that distinct sets of blocks derived from different mountains have followed the lines of the different valleys. The blocks in the valley of the Rhine have come from the Grissons; those by the lake of Zurich and the course of the Limmat were drifted from Glaris; blocks from the source of the Reuss have followed this river; the blocks of the Aar, and the slopes of the neighbouring Jura have come from the range of the Oberland of Berne. From these facts, and the circumstance that the height to which the blocks have ascended the Jura, no doubt can be entertained, that the currents flowed from these mountains in many directions, and followed the line of the present valleys. It appears the most probable view of these phenomena that a general and violent convulsion of the Alps, while they were surrounded by water, caused powerful currents to rush away from the axis of movement, bearing ice rafts loaded with the loosened rocks.

"This explanation appears satisfactory to Venturi, reasoning on the phenomena of the south side of the Alps; it has been suggested from the case

of the blocks on the drainage of the St. Lawrence, and is proposed as the most probable view of the facts observed concerning the multitude of rock masses which have crossed the Baltic, and dropped in heaps on the plains of Northern Germany, Poland, and Russia, from the Ems and the Weser, to the Dwina, and even the Neva. These blocks are grouped in narrow elliptical areas, with the longer axis pointing north and south, or towards the Baltic; they often lie on the surface, especially the larger blocks, hardly ever at great depths. They consist principally of granite, sienite, porphyry, and transition limestones, with characteristic fossils which can be exactly paralleled in the southern parts of Sweden and nowhere else. . . . . The blocks are more numerous on the Swedish side of the Baltic, nearer their origin, but not larger. Worn and polished surfaces among the primary rocks of Sweden are attributed to the transport of heavy bodies.

"The dispersion of blocks from the Cambrian group of mountains is extremely remarkable. . . . . . In their passage, three ridges of anciently elevated land, and two deep geologically ancient vales were crossed; yet the water so far respected the elevations of ground now existing, as not to cross the Penine chain at more than one, and that *the lowest point opening directly to the west*, and to avoid the highest part of the oolitic moors. What renders this more curious and complete is the circumstance that one of the valleys crossed (the vale of Eden) 1,000 feet below the origin of the granite, and 1,000 feet below Stainmoor, is a valley caused by dislocation of the carboniferous system *prior to the new red sandstone era*, and the date of the dispersion of the blocks is since the newest tertiaries in the north of England." . . . . .

Somewhat further on, he continues—

"It is evident from all that has been proved, inferred, and admitted on the subject of the *erratic blocks*, that they were derived from particular mountain groups, drifted thence to limited, though considerable distances, along lines which respect the present levels of the country, both as to height and direction. They lie generally at the surface of the superficial marine diluvium, and speak plainly of great and violent convulsions. Yet it is already certain that they are monuments of merely local, however violent, disturbances; not proofs of universal or even very great or general floods."

And finally, on this subject, from Professor Phillips—

"The clay (in the diluvial accumulations of Holderness) in particular, usually of a brown or blue colour, is uncommonly full of pebbles and large boulders (from a hundred-weight to a ton and upwards), of sandstones, limestones, and greenstones, derived from Western Yorkshire; slates, porphyries, and granite, from Cumberland; diallage rocks, mica-slate, with garnets, gneiss, &c., and referable either to Scotland or Norway, and many stones of whose origin no satisfactory account can be given.

"The aggregation of the mass is such as utterly to forbid belief that it was heaped together by anything short of a mighty mechanical agency, which in its tempestuous violence permitted none of that distinction of specific gravity, form, or magnitude of the masses to appear in the deposit, which is invariably seen in every case of gradual or intermitting effect of ordinary streams or tides."*

* Treatise on Geology, pp. 205, 206, 208—210, 215.

Mr. Ansted corroborates these statements by the following remarks respecting travelled debris:—

"It seems reasonable," says he, "to assume, that the first elevation of great masses of land, some part of which now consists of lofty mountain peaks of granite and of igneous rocks, should have been accompanied by local disturbances of the bed of the sea, producing waves capable of transporting large quantities of broken rock, and that by a succession of similar movements these fragments might be conveyed, being more and more pounded and rolled, to a distance of many miles, or even hundreds of miles. Perhaps it may be because the quantity of land elevated in the Arctic circle was lifted up under different circumstances, and in more uniform, dome-shaped, and larger masses, producing more powerful waves; that the fragments broken off from the old rocks of Scandinavia, Lapland, and northern Russia, and the northern parts of our own island (which have all partaken of this movement and its consequences) have been farther transported, and are deposited in more regular, more widely spread, and more characteristic beds of gravel than the Alpine rocks, whose range is, in every respect, more limited. The whole subject of the distribution of gravel is, however, one abounding in difficulties which have as yet been only partially explained. . . . . . Whatever the cause or causes may have been, the distribution of numerous blocks of stone, sometimes rounded, but more frequently angular, and of every size and shape, and the removal of these to various distances from the parent rock, are facts distinctly made out. Such blocks, also, are not confined to Northern Europe, but are met with both in North and South America, and in other parts of the world. It is, however, certain that true gravel, with rolled blocks of stone, is not universally distributed; and the effects thus produced have been as partial as they were frequent, the result being quite different. It thus happens that, while in most cases common gravel, or transported and erratic blocks and boulders have been deposited, we find elsewhere only great masses of mud and clay, mixed with stones, sand, or any other material drifted into recesses, and left there by the iceberg, or the retiring wave."*

Mr. Miller, when describing, so inimitably, a few of the first of those days of labour which eventually led to distinction, thus touches on "the boulder formation" with which we are now engaged:—

"The evening furnished me," says he, "with still further cause of wonder. We raised another block in a different part of the quarry, and found that the area of a circular depression in the stratum below was broken and flawed in every direction, as if it had been the bottom of a pool recently dried up, which had shrunk and split in the hardening. Several large stones came rolling down from the diluvium in the course of the afternoon. They were of different qualities from the sandstone below, and from one another; and, what was more wonderful still, they were all rounded and water-worn, as if they had been tossed about in the sea, or the bed of a river, for hundreds of years. There could not, surely, be a more conclusive proof that the bank which had enclosed them so long could not have been created on the rock on which it rested. No workman ever manufactures a half-worn article, and the stones were all half-worn! And if not the bank,

* Ancient World, pp. 323—326.

why then the sandstone underneath? I was lost in conjecture, and found I had food enough for thought that evening, without once thinking of the unhappiness of a life of labour. The immense masses of diluvium which we had to clear away rendered the working of the quarry laborious and expensive, and all the party quitted it in a few days to make trial of another that seemed to promise better. . . . . . I soon found I was to be no loser by the change. Not the united labours of a thousand men for more than a thousand years could have furnished a better section of the geology of the district than this range of cliffs. It may be regarded as a sort of chance dissection on the earth's crust. We see in one place the primary rock, with its veins of granite and quartz, its dizzy precipices of gneiss, and its huge masses of hornblend; we find the secondary rock in another, with its beds of sandstone and shale, its spars, its clays, and its nodular limestones.

"We discover the still little-known but highly interesting fossils of the old red sandstone in one deposition; we find the beautifully preserved shells and lignites of the lias in another. There are the remains of two several creations at once before us. The shore, too, is heaped with rolled fragments of almost every variety of rock, basalts, ironstones, hyperstones, porphyries, bituminous shales, and micaceous schists. In short, the young geologist, had he all Europe before him, could hardly choose for himself a better field."*

Mr. Lyell, when treating of this division of geological research, says—

"Between the superficial covering of vegetable mould and the subjacent rock there usually intervenes in every district a deposit of loose gravel, sand, and mud, to which the name of *alluvium* has been applied. . . . . .

"A partial covering of such alluvium is found alike in all climates, from the equatorial to the polar regions, but in the higher latitudes of Europe and North America it assumes a distinct character, being very frequently devoid of stratification, and containing large fragments of rock, some angular, and others rounded, which have been transported to great distances from their parent mountains.

". . . . . Mention," he continues, "was made in a previous chapter of an ancient alluvium in the North of Europe, called the 'boulder formation.' . . . . .

"This formation consists of mica, sand, and clay, sometimes stratified, but often wholly devoid of stratification, for a depth of more than one hundred feet. To this unstratified form of the deposit the name of *till* has been applied in Scotland. It generally contains numerous fragments of rocks, some angular, and others rounded, which have been derived from formations of all ages, both fossiliferous, volcanic, and hypogene, and which have often been brought from great distances. Some of the travelled blocks are of enormous size, several feet or yards in diameter; their average dimensions increasing as we advance northwards. . . . . . Although a large proportion of the boulder deposit is made up of fragments brought from a distance, and which have sometimes travelled many hundred miles, the bulk of the mass in each locality consists of the ruins of subjacent or neighbouring rocks; so that it is red in a region of red sandstone, white in a chalk country, and grey or black in a district of coal or coal shale.

* Old Red Sandstone, pp. 40, 41.

"That the erratics of Northern Europe have been carried southward, cannot bé doubted; those of granite, for example, scattered over large districts of Russia and Poland, agree precisely in character with rocks of the mountains of Lapland and Finland; while the masses of gneiss, sienite, porphyry, and trap, strewed over the low sandy countries of Pomerania, Holstein, and Denmark, are identical in mineral character with the mountains of Norway and Sweden. It is found to be a general rule in Russia, that the smaller blocks are carried to greater distances from the point of their departure than the larger; the distance being sometimes 800 and even 1,000 miles from the nearest rocks from which they were broken off; the direction having been from north-west to south-east, or from the Scandinavian mountains over the seas and low lands to the south-east." . . . . Again—"Now, some or all of the marks enumerated, the moraines, erratics, polished surfaces, striæ, caldrons, and perched rocks, are observed in the Alps at great heights above the present glaciers, and far below their actual extremities; also in the great valley of Switzerland, 50 miles broad; and almost everywhere on the Jura, a chain which lies to the north of this valley. The erratics, moreover, which cover it, present a phenomenon which has astonished and perplexed the geologist for more than half a century. No conclusion can be more incontestable than that these angular blocks of granite, gneiss, and other crystaline formations, came from the Alps, and that they have been brought from a distance of 50 miles and upwards across one of the widest and deepest valleys of the world, so that they are now lodged on the hills and valleys of a chain, composed of limestone and other formations, altogether distinct from those of the Alps.

"Their great size and angularity, after a journey of so many leagues, has justly excited wonder; for hundreds of them are as large as cottages; and one in particular, celebrated under the name of Pierre à Bot, rests on the side of a hill, about 900 feet above the lake of Neufchatel, and is no less than 40 feet in diameter. . . . . . But in Scotland the points from which the Grampian boulders have been conveyed are much lower, and those to which they have been carried equally remote. One fragment of the mica-schist, weighing from 8 to 10 tons, has been pointed out by Mr. Mac Laren as occurring at the height of 1,100 feet above the sea on the Pentland Hills; the nearest mountain composed of this formation being 50 miles distant.

"It was stated that the boulder deposit of Russia reposed on strata containing recent marine shells, but the *till* in Scotland rests immediately on the older rocks, and is covered by stratified sand and clay, which usually contain no fossils. At certain points, however, near the coast, as for example, in the estuaries of the Tay and Clyde, marine shells have been discovered in strata overlying the till. They occur on the Clyde at the height of 70 feet; but the deposit, of which they form an integral part, rises in the same country to an elevation of several hundred feet. Although between 80 and 90 per cent. are of recent species, the remainder are unknown; and even many which are recent, now inhabit more northern seas, where we may hereafter hope to find living representatives of some of the unknown fossils. From the arctic character of this fauna, which resembles that of Quebec, before described, we may infer that these strata and the subjacent till are of higher antiquity than some parts of the boulder deposit of northern Europe."*

* Lyell's Elements, vol. i. pp. 164, 165, 222—224, 248, 255.

And finally, with respect to this group of rocks, M. de la Beche says—

"The origin of the various transported gravels, sands, blocks, and rocks, and other mineral substances scattered over hills, plains, and on the bottoms of valleys, often referred to one epoch, may belong to several. At the present time there would appear to be three principal opinions connected with the subject.

"One supposes the transport to have been effected at one and the same period. Another, that several catastrophes have produced these superficial gravels; while a *third* would seem to refer them to a long continuance of the same intensity of natural forces as that which we now witness. . . . . These different opinions, though they cannot each be correct in explanation of all the observed facts, may each be so in part, and it were to be wished that the phenomena here arranged under one head solely for convenience, were examined without the controul of a preconceived theory." . . . .

After detailing a great many instances of transported boulders, blocks, and other mineral detritus, and combating the opinion of their being produced by atmospheric waste, he goes on to say—

"The probability, therefore, as far as the above facts seem to warrant, is, that a body of water has proceeded from north to south over the British Isles, moving with sufficient velocity to transport fragments of rock from Norway to the Shetland isles and the eastern coast of England; the course of such a body of water having been modified and obstructed among the valleys, hills, and mountains which it encountered; so that various minor and low currents having been produced, the distribution of the detritus has been in various directions.

"If the supposition of a mass of waters having passed over Britain be founded on probability, the evidences of such a passage or passages should be found in the neighbouring continent of Europe; and the general direction of the transported substances should be the same. Now, this is precisely what we do find. In Sweden and Russia, large blocks of rock occur in great numbers, and no doubt can be entertained that they have been transported southward from the north. . . . . Proceeding south, the course of the waters seems to have continued in that direction over the low districts of Germany to the Netherlands, depositing large blocks in their passage; these blocks are proved by their mineralogical composition to have been derived from rocks known to exist in the northern regions.

"Such a movement as this over part of Europe would, if the supposition of the mass of waters were correct, be observed in other northern regions, for the waters thrown into agitation would cause waves around the centre of disturbance. In America, therefore, we should expect to find marks of such a deluge, the evidences pointing to a northern origin. Now, in the northern regions of that country we do find marks of an aqueous torrent bearing blocks and other detritus before it, the lines of their transport pointing from the northward, according to Dr. Bigsby, and reminding us of the same appearances observed in Sweden and Germany. The quantity of transported matter covering various large tracts in North America, seems quite equal to that scattered over Northern Europe; and as they both point one way, we can scarcely refuse to admit that the cause of the disturbance or disturbances was towards the north; the undulations of the water having

been caused by some violent agitation, perhaps beneath the sea in those regions, for it is by no means necessary that it should be above its level. . . . . . Solutions of the problem of erratic blocks seem not very practicable at present, and our attempt at general explanations can be considered little else than conjectures, that may appear less or more probable."*

Whilst these interesting evidences are vividly before the mind, if we recur to what has been said of the disintegrating influence exercised by the protruded rocks upon the strata through which they burst, when the earth first revolved around its axis; afterwards take into consideration the infinite number of fragments, of all dimensions and kinds, which were spread abroad from each elevated chain, as it assumed its relative height and present form; and then direct the attention to the rush of water which, at the same time, was sweeping with inconceivable rapidity from the poles towards the equator, acquiring a westerly direction as it advanced; and take into account its capacity as a carrier of debris, no difficulty will any longer be found in accounting for the distance travelled over, or for the relative direction in which so many of the boulders are found, with respect to the rocks from which they appear to have been torn. For, on viewing the subject, under these impressions, with reference to what was then taking place, the following considerations present themselves almost spontaneously:—

That the fragments would be massive and numerous in proportion to the height of the mountain ranges from whence they emanated, or what is precisely the same, in proportion to the violence with which the protruded rocks perforated the superincumbent strata. That these effects would be modified considerably by the nature of both the perforating and the perforated substances. That they would be removed to distances in direct proportion to the velocity of the conducting fluid, and inversely as their respective masses.

That the evidence of the distance over which they may have travelled, such as the rounding of their angles and other asperities—the usual symptoms of attrition on mineral matter—would be the greater the nearer they are found to the equatorial regions, and the more moderate their size. That the effects of local formations in determining their present relative sites would be rather complexly manifested, from the influential circumstance, that, as the land was simultaneously assuming its present form, the effects of its undulations, as a modifying cause, would be exercised and be now apparent by the results, in direct proportion to the distance between the sites of the fragments and their parent rock; or, in other words, in proportion to the time they were in motion, in consequence of the earth having been all the while approaching nearer and nearer to its perfect form of equilibrium under rotation.

Assuming these, therefore, to be the conditions of the problem, it appears evident, that as the specific gravity of the boulders, rela-

* Manual, pp. 164, 171, 173, 177.

tively to the fluid, was the same *everywhere;* while the velocity of the latter would be in proportion to the latitude, there should be found, as the first and most immediate result, that the distances between the actual positions of the boulders and the place from whence they came will be greatest in highest latitudes; and as the current, in flowing towards the equator, acquired a westerly direction, by a composition of these two forces; the boulders of the northern hemisphere should be generally in situations bearing south-westerly from the places of their origin; the westerly deviation being more remarkable the nearer to the equator, a conclusion, agreeing perfectly with what is shown in a clear and intelligible manner, by the foregoing evidences, to be the case.

It must be understood to follow, as strict deductions from what has been here advanced, that where detached masses are enormously great, and have been transported to only short distances from their parent rocks, they would, in a corresponding manner, be but slightly diverted from their equatorial course, whether they had their origin in the northern or in the southern hemisphere.

And as the earth, during the same brief period, was assuming its present exterior form—that of equilibrium under rotation —there would occur numberless instances, where immense fragmental masses (and the more massive the more likely to happen), after being swept over considerable intermediate spaces, may have been arrested by the upheaving shoulders of some mighty mountain chain, as it interposed itself like a barrier to their onward course; may have been carried up to greater elevations along with it, whilst the surface over which these boulders had previously and but recently travelled, may have simultaneously sunk down, as a co-effect of the elevation of the intercepting range, and the space between have become a broad and deep valley, thereby facilitating the onward equatorial course of the rushing waters, which thus left those great landmarks of their path behind them. I feel persuaded, that where circumstances are favourable for the examination and the identification of blocks and boulders, these results will be found to have taken place, and thereby furnish the most undeniable evidence of the correctness of these conclusions.

The influence exercised, by the *form* of the earth in modifying the relative sites of these rocky fragments, when their other prognostics, such as the distance of their route, &c., are taken into account, together with a candid and attentive examination of the whole phenomena, will be found to yield the most satisfactory results, and the most perfect elucidation of those geological manifestations which abound; and will afford one of the most convincing tests of the soundness of the Dynamical Theory. And, that these influential conditions, and these conditions alone, will solve the enigma, which hitherto has baffled all attempts to explain it, namely—the manifest indifference shown, during their projectile progress, by several

immense boulders, located among the Alps, to the enormous mountains which at present intervene between them and the places of their origin; giving rise to innumerable hypothetical conclusions, and to the necessity of calling in the aid of wonder-working *debacles* to account for their translation; while, at the same time, the comparatively smaller and more distant travelled blocks of the north of England present the contradictory evidence of having paid every respect to the sinuosities of the land over which they voyaged, having "been drifted in certain lines, so as to show that the causes, whatever they were, which produced the phenomena, were not capable of overcoming, except in a limited degree, the natural obstacles of the country."* In the former case, the boulders must have been removed simultaneously with the rising of the land, and during the time that the waters were in violent motion; whereas, in the latter, they having continued their route for a greater length of time, were influenced, at every step, by two conjoint retarding causes, the more perfect formation of the land, and the decreasing rapidity of the transporting medium, as it approached its static form and condition of equilibrium.

Indeed, so convinced am I of the soundness of these conclusions, that I venture to stake the validity of this part of the Dynamical Theory on the assertion, that whenever the travelled boulders of the *southern* hemisphere are examined by impartial geologists, they will be found to occupy corresponding positions, with respect to the rocky formations whence they, too, have proceeded. That is, it will be discovered, *in general*, that they have been removed in a direction towards the *north-west*, with all the corresponding inflexions, which similar local circumstances are found to have produced on those of the northern hemisphere.†

In addition to those observations on the evidences afforded by the "Erratic Block Group," it is remarked, that there is scarcely any geological data more strongly corroborative of the Dynamical Theory, than the abounding widely spread deposits of rolled pebbles which form a part of the ground. When the unstratified rocks burst through the superincumbent strata, innumerable fragments of all descriptions, shapes, and sizes, must have been scattered about as the immediate consequence; but *not one of them could have been round when torn off the parent rock:* so certainly as the one rock perforated

* Professor Phillips, before the British Association, at Bristol, Sept., 1836.

† The assertion contained in this passage, which was written in 1836, has been fully verified intermediately by the investigations of those geologists who have since then had opportunities of visiting the southern regions of the globe, more especially in Chili, Bolivia, and Peru, where boulders and massive fragments, resulting from this great day's work, and general commotion over all the earth's surface, are found strewed everywhere around the flanks and amongst the hollows of the huge and far-stretching Cordillera, themselves one of the most striking monuments of protorotation long posterior to the deposition and induration of our sphere's concentric stratified envelope, the work of protracted darkness and non-rotation. For one example, see Lyell's Elements, vol. i. p. 251.

and passed another, so certainly would the detached fragments be angular, ragged, and pointed. On the other hand, when this convulsion took place, had the whole not been enveloped in much water—a hypothetical combination which might be supposed to have occurred if *heat* or *fire* had caused the catastrophe—then the fragments alluded to would have remained almost as angular and as ragged and pointed as they were when detached. Had the displacement, and its natural consequences, occurred in the midst of water, *without any peculiar impetus*, such as a rush from the poles towards the equator, to complete the figure or static condition of rotation, it is not at all probable, that the stones and fragments, to which I refer, would or could have assumed the perfect appearance of much attrition and of distant travel which those beds of pebbles do. They evidence, by their perfect sphericity, in many instances, when coupled with the solidity of their material, that it was no *common* flood, no *short* space travelled over, nor any *moderate* speed which conferred on them their smoothly rounded forms, and which have acquired for them the designation of "*travelled* fragments."

It is equally as satisfactory to reflect, on taking another view of the case, that without their presence in the precise conditions in which they are found, all the assumptions of this Treatise would have been incomplete, and liable hereafter to have been considered erroneous. And thus, the rolled pebbles afford both positive and negative proof in favour of the cosmogany which is here inculcated.

It is with peculiar satisfaction I am thus enabled to close the geological evidences, in this department, for the truth of the *Dynamical Theory*, with a class of phenomena, derived from that science, so universal and so admirably adapted as are the components of the "erratic block group," both by their character and their durability, to point out the form which the earth assumed on being caused to revolve around its axis. No evidences could possibly have been more appropriate than these "boulders," tangible as they are by the senses, and everywhere to be found. Most heartily ought we to thank the Creator for having permitted that these effects should have proceeded from natural causes, in order, that along with the other designs, which they were intended to fulfil, they should afford the most undeniable evidence, *that when torn asunder from their parent rocks, and strewed over and imbedded in the surface of the surrounding soil, the globe was in the act of receiving from His almighty hand, "who weighed out its hills in His balance," the identical inflexions of surface which, to the present moment, it retains.*

SECTION V.

GEOLOGICAL PHENOMENA RESULTING FROM THE EARTH'S PROTOROTATION.

CHAPTER XXVIII.

Brief recapitulation of the principal subjects of this Section. Uranographical effects of the transformation of the earth, from a non-rotating sphere to a spheroid of rotation. Series of evidences. Precession of the equinoxes astronomically explained, and its bearing on the question pointed out. Geologically confirmed. Chronological data to show at what period the longer axis of the solar ellipse coincided with the equinoxes. Conclusion drawn from a combination of these evidences, that the precession of the equinoxes commenced with, and is dependent for its existence on the earth's protorotation; and, that the commencement of the two was coeval, and their periods have had the same duration. A combination of these established positions, with the fact of "matter never engendering motion in itself," employed to show, that the earth's motions must have originated from the Creator, and that the Creator is GOD.

ON reviewing the leading points of this protracted section it will be perceived that, first of all, evidences of a *mechanical* character were adduced to prove, that the earth, which, during the period of darkness circulated around the unillumined sun without diurnal motion, was, by the formation of the light, and its division from the darkness, caused to revolve around its axis. Having dwelt sufficiently on that particular point I proceeded to enquire, in continuation what were likely, *theoretically*, to have been the results of this new motion upon the general outlines of the globe. After these were defined, as nearly as possible, a minute and lengthened investigation was entered into, which concluded by determining, satisfactorily, that not only all *geological* phenomena, but likewise the *greater general elevation* of *land* within the equatorial regions, and the formation of *continental ridges* and *oceanic hollows* accorded with these theoretical conclusions.

In conducting the geological enquiries I attended both to the *external* evidences afforded by the action of one rock upon another, and also to the *internal* evidences arising from the mineralogical structure of the primary and older secondary rocks, supposing them to have been moved from where they were considered, in the pre-

vious chapters, to have been formed. In these investigations, there were included the mineral veins, dykes, and fissures, and the metallic lodes, and it was made manifest that *they*, too, could be satisfactorily accounted for by the same theory. Going on, afterwards, to the sedimentary rocks, which owe their origin to the deposition of *debris*, spread abroad by the elevation of mountain chains, it was shown, that with the exception of some of the more recent of the tertiary, whose origin was hinted at in passing, they, likewise, correspond in geological developments with what might, *a priori*, have been expected from the first rotation of the earth around its axis, after induration had taken place at the period alluded to. And the whole was closed in by a brief description of the "erratic block group," which was also found to be susceptible of easy elucidation, by the facts and arguments brought to bear upon it.

Under these concurring and favourable circumstances, looking upon the *geological* and *mineralogical* evidences as being uninterruptedly linked together from first to last; and feeling assured that the proofs in favour of the Dynamical Theory have been, throughout, most persistent; it is now considered we may safely conclude, as a final deduction from the whole, *that the first revolution of the earth around its axis took place* AFTER *the formation of those materials which now constitute the independent coal measures, and immediately* BEFORE *the deposition of the new red sandstone, the oolitic, and the cretaceous groups:* from which conclusion three important corollaries necessarily follow:—

1. That the period during which the earth revolved around the sun *without rotatory motion*, extended from the instant of its being translated in space at "the beginning," from the first symptom of stratification until the entire deposition of the material which now constitutes the coal measures.

2. That as the protuberance of its equatorial regions arises from its *diurnal* rotation, and this owes its origin to the formation of the light, and its division from the darkness, its excess of equatorial diameter *can have existed only since the date recorded in Scripture as being that of the formation of the light.*

And 3. As a change of form would produce a corresponding effect on the *astronomical* relations of our sphere, this would undoubtedly be perceptible to astronomers, by their accurate investigations responding to the reverberation which took place on that account from the allied but distant bodies of our system; and should leave upon their records, corresponding evidences of a change in the earth's uranographical phenomena, indicative of that alteration of form which geology leads us to consider it underwent; while the exact nature of those deductions should assign the precise period or nearly so, when this perturbation was first perceptible in the motions of our planet. That, should such be the case, all these views would be corroborated by the testimony of a science dedicated

to the investigation of laws which govern regions of space far beyond the sphere we tread upon; and we would thereby enjoy the satisfaction of beholding these sciences mutually shedding their lights on each other, and unitedly conspiring to the advancement and establishment of the TRUTH.

In order to discover whether such, in reality, is the case, let us attend to what is stated in the *seventh* Theorem, "*That owing to a secular motion in the position of the major axis of the solar ellipse, arising from a direct motion of the perigee and the retrogradation of the node of the earth's equator on the ecliptic (called the precession of the equinoxes), which conjointly accomplish an entire revolution in* 20,984 *years, a corresponding, gradual, but entire change is going on in the relative positions of the major axis and the line of the equinoxes; which, about* 4,000 *years before the Christian era, coincided with each other.*

"*And that this secular change is the necessary consequence of the rotation of the earth, and the disturbing action of the sun and moon on the redundant matter accumulated about the earth's equator.*"

These results being deduced from principles in astronomy, not very apparent at first sight, and depending on two motions entirely distinct in their nature and origin, they will require to be partially analyzed and laid open to the view, by explanations drawn from the same source which furnished the materials for the theorem. In doing this, I shall commence with the "direct motion of the perigee," more with the design of eliminating it from the argument, than from any immediate tendency it has to aid our convictions; the phenomena which principally interests the general inquiry being the *retrogradation of the node of the earth's equator on the ecliptic.*

The following extract proves the effect produced on our satellite in consequence of the redundant matter accumulated in the equatorial regions, and the reciprocal light which this sheds upon the external form and the internal structure of the earth:—

"The moon is so near," says Mrs. Somerville, "that the excess of matter at the earth's equator occasions periodic variations in her longitude, and also that remarkable inequality in her latitude, already mentioned as a nutation in the lunar orbit, which diminishes its inclination to the ecliptic, when the moon's ascending node coincides with the equinox of spring and augments it when that node coincides with the equinox of autumn.

"As the cause must be proportional to the effect, a comparison of these inequalities, computed from theory with the same given by observation, shows that the compression of the terrestrial spheroid, or the ratio of the difference between the polar and the equatorial diameters to the diameter of the equator is 1-305.05. It is proved analytically, that if a fluid mass of homogeneous matter, whose particles attract each other inversely as the square of the distance, were to revolve about an axis as the earth does, it would assume the form of a spheroid, whose compresssion is 1-230. Since that is not the case, the earth cannot be homogeneous, but must decrease in density from its centre to its circumference. Thus, the moon's eclipses

show the earth to be round; and her inequalities not only determine the form, but even the internal structure of our planet; results of analyses which could not have been anticipated." And again, "The larger planets rotate in shorter periods than the smaller planets and the earth. Their compression is consequently greater, and the action of the sun and their satellites occasions a nutation in their axes, and a precession of their equinoxes, similar to that which obtains in the terrestrial spheroid, from the attraction of the sun and moon on the prominent matter at the equator."*

Having thus become briefly acquainted with the nature of the slow secular perturbation alluded to, which, however, but slightly affects the arrangement, I shall next proceed to enquire into that of "*the retrogradation of the node of the earth's equator on the ecliptic;*" and beg that particular attention may be paid to the important evidences about to be brought forward:—

"The problem," says Professor Playfair, "which Newton had thus concluded, enabled him to resolve one of still greater difficulty. The *precession*, that is, the retrogradation of the equinoctial points, had been long known to astronomers; its rate had been measured by a comparison of ancient and modern observations, and found to amount to nearly 50″ annually, so as to complete an entire revolution of the heavens in 25,920 years. Nothing seemed more difficult to explain than this phenomenon, and no idea of assigning a physical or mechanical cause for it had yet occurred, I believe, to the boldest and most theoretical astronomers. The honour of assigning the true cause was reserved for the most cautious of philosophers. He was directed to this by a certain analogy observed between the precession of the equinoxes and the retrogradation of the moon's nodes, a phenomenon to which his calculus had been already successfully applied. The spheroidal shell or ring of matter which surrounds the earth, as we have just seen, in the direction of the equator, being one-half above the plane of the ecliptic, and the other half below, is subjected to the action of the solar force, the tendency of which is to make this ring turn on the line of its intersection with the ecliptic, so as ultimately to coincide with the plane of that circle. This, accordingly, would have happened long since, if the earth had not revolved on its axis. The effect of the rotation of the spheroidal ring from west to east, at the same time that it is drawn down toward the plane of the ecliptic, is to preserve the inclination of these two planes unchanged, but to make their intersection move in a direction opposite to that of the diurnal rotation, that is from east to west, or contrary to the order of the signs of the Zodiac."†

In another part of his work, when reviewing the *Mechanique Celeste* of M. La Place, he says—

"With the questions of the figure of the earth, and the flux and reflux of the sea, that of the precession of the equinoxes is closely connected; and La Place has devoted his fifth book to the consideration of it. . . . Newton was the first who turned his thoughts to the physical cause of this appearance; and it required all the sagacity and penetration of that great man to discover this cause in the principle of universal gravitation. The effect of

* Connexion of the Sciences, pp. 48, et seq.
† Playfair's Works, vol. ii. pp. 411, 412.

the forces of the sun and moon on that excess of matter which surrounds the earth at the equator, must, as he has proved, produce a slow angular motion in the plane of the latter, and in a direction contrary to that of the earth's rotation. . . . . .

"That excellent mathematician, D'Alembert, gave a solution of this problem that has never been surpassed for accuracy and depth of reasoning, though it may have been for simplicity and shortness. . . . . .

"La Place has gone over the same ground, more that he might give unity and completeness to his work, than that he could expect to add much to the solution of D'Alembert. As he has proceeded in a more general manner than the latter, he has obtained some conclusions not included in this solution. He has shown, that the phenomena of the precession and nutation must be the same in the actual state of our terraqueous spheroid, as if the whole were a solid mass, and that is true, whatever be the irregularity of the depth of the sea. He shows also, that currents in the sea, rivers, trade winds, even earthquakes, can have no effect in altering the earth's rotation on its axis. The conclusions with regard to the constitution of the earth, that are found to agree with the actual quantity of the precession of the equinoxes are, that the density of the earth increases from the circumference towards the centre; that it has the form of an ellipsoid of revolution; and that the compression of this spheroid at the poles is between the limits of 1-304th and 1-578th part of the radius of the equator."*

"It has been shown," says Mrs. Somerville, in a passage to which I have already had occasion to refer, "that the axis of rotation is invariable on the surface of the earth; and observation as well as theory prove, that were it not for the action of the sun and moon on the matter at the equator, it would remain exactly parallel to itself in every point of its orbit. The attraction of an external body not only draws the spheroid towards it, but, as the force varies inversely as the square of the distance, it gives it a motion about its centre of gravity, unless when the attracting body is situate in the prolongation of one of the axes of the spheroid. The plane of the equator is inclined to the plane of the ecliptic at an angle of 23° 27.38″ 81, and the inclination of the lunar orbit to the same is 5° 8.47″ 9. Consequently, from the oblate figure of the earth, the sun and moon acting obliquely and unequally on the different parts of the terrestrial spheroid, urge the plane of the equator from its direction, and force it to move from east to west, so that the equinoctial points have a slow retrograde motion on the plane of the ecliptic of 50″ 10 annually. The direct tendency of this action is to make the planes of the equator and ecliptic coincide, but it is balanced by the tendency of the earth to return to stable rotation about the polar diameter, which is one of its principal axes of rotation. Therefore the inclination of the two planes remains constant, as a top spinning preserves the same inclination to the plane of the horizon. Were the earth spherical this effect would not be produced, and the equinoxes would always correspond with the same points of the ecliptic, at least as far as this kind of motion is concerned; but another and totally different cause which operates on this motion has already been mentioned.

"The action of the planets on one another, and on the sun, occasions a very slow variation in the position of the plane of the ecliptic, which affects its inclination to the plane of the equator, and gives the equinoctial points

* Playfair's Works, vol. iv. pp. 305—307.

a slow but direct motion on the ecliptic of 0″ 31 annually, which is entirely independent of the figure of the earth, and would be the same if it were a sphere. Thus the sun and moon, by moving the plane of the equator, cause the equinoctial points to retrogade on the ecliptic; and the planets, by moving the plane of the ecliptic, give them a direct motion, though much less than the former. Consequently, the difference of the two is the mean precession, which is proved, both by theory and observation, to be about 50″ 10 annually. . . . . .

"Moving at this rate annually, the equinoctial points will accomplish a revolution in 25,868 years. . . . . .

And in conclusion from this instructive writer—

"The mean annual precession is subject to a secular variation; for, although the change in the plane of the ecliptic in which the orbit of the sun lies, be independent of the form of the earth, yet by bringing the sun, moon, and earth into different relative positions, from age to age, it alters the direct action of the two first on the prominent matter at the equator; on this account the motion of the equinox is greater by 0″.455 now than it was in the time of Hipparchus. Consequently, the actual length of the tropical year is about 4″.21 shorter than it was at that time. The utmost change that it can experience from the cause amounts to 43 seconds. Such is the secular motion of the equinoxes. But it is sometimes increased and sometimes diminished by periodic variations, whose periods depend upon the relative positions of the sun and moon with regard to the earth, and which are occasioned by the direct action of these bodies on the equator."*

Sir John Herschel thus explains this astronomical question:—

"The determination of the vernal equinox is a point of great importance in practical astronomy, as it is the origin or Zero point of right ascension. Now, when this process is repeated at considerably distant intervals of time, a very remarkable phenomenon is observed, namely, that the equinox does not preserve a constant place among the stars, but shifts its position, travelling continually and regularly, although with extreme slowness, *backwards*, along the ecliptic, in a direction from east to west, or the *contrary* to that in which the sun appears to move in that circle. . . . . . The amount of this motion by which the equinox *retrogrades* on the ecliptic, is 0° 0′ 50″.10 *per annum*, an extremely minute quantity, but which, by its continual accumulation from year to year, at last makes itself very palpable. . . . . . . Since the formation of the earliest catalogue of stars on record, the place of the equinox has retrograded already about 30°. The period in which it performs a complete tour of the ecliptic is 25,868 years." . . . . .

In continuation, after describing the immediate uranographical effects of the precession of the equinoxes, in giving rise to a uniform increase of longitude to all the heavenly bodies, and the interesting results which this, in turn, occasions, he goes on to say—

"These two phenomena, namely, *precession* and *nutation*, it is true, belong, theoretically speaking, to one and the same general head, and are intimately connected together, forming part of a great and complicated chain of consequences flowing from the earth's rotation on its axis: but it will be of advantage to consider them separately.

* Connexion of the Sciences, pp. 91—93.

"It is found, then, that in virtue of the uniform part of the motion of the pole, it describes a circle in the heavens around the pole of the ecliptic as a centre, keeping constantly at the same distance of 23° 28′.0 from it, in a direction from east to west, with a velocity that the annual angle described by it, in this, its imaginary orbit, is 50″.10; so that the whole circle will be described by it in the above-mentioned cycle of 25,868 years. . . . . . This motion gives rise to the retrograde motion of the equinoxes.

"The pole is nothing more than the vanishing point of the earth's axis. This point, then, having such a motion as described, it necessarily follows, that the earth's *axis* must have a conical motion. We may form the best idea of such a motion by noticing a child's peg-top, when it spins, not upright, or that amusing toy, the teetotum, which when delicately executed, and nicely balanced, becomes an elegant philosophical instrument, and exhibits in the most beautiful manner, the whole phenomenon, in a way calculated to give at once a clear conception of it as a fact, and a considerable insight into its physical cause as a dynamical effect. . . . . .

"It will be shown in a subsequent chapter, that *precession* and *nutation* are necessary consequences of the rotation of the earth, combined with its elliptical figure, and the unequal attraction of the sun and moon on its polar and equatorial regions."

And, in conclusion, from the same work, on this particular subject—

"The precession of the equinoxes, as we have shown, consists in a continual retrogradation of the node of the earth's equator on the ecliptic, and is, therefore, obviously an effect so far analogous to the general phenomenon of the retrogradation of the nodes of the orbits on each other.

"The immense distance of the planets, however, compared with the size of the earth, and the smallness of their masses, compared to that of the sun, puts their action out of the question in the enquiry of its cause, and we must, therefore, look to the massive though distant sun, and to our near though minute neighbour the moon, for its explanation. This will, accordingly, be found in their disturbing action on the redundant matter accumulated on the equator of the earth, by which its figure is rendered spheroidal, combined with the earth's rotation on its axis. It is to the sagacity of Newton that we owe the discovery of this singular mode of action."*

Before any reliable conclusion can be drawn from these lucid and concurring evidences, I must endeavour, by investigation, to ascertain the era when the longer axis of the solar ellipse coincided with the equinoxes. This may be considered accomplished by the following quotations, although there is a difference in the particular coincident equinox assigned by some of the writers.

* Astronomy, in Cab. Cyc., American edition, pp. 161—166, 309. I take occasion to recommend to all who may have the opportunity, to peruse attentively the whole of Sir John Herschel's luminous exposition of this intricate astronomical phenomenon, which unfortunately is too long to be given here, and cannot be abridged, assured that while they derive pleasure and information by so doing, they will be more than ever convinced that precession and nutation are intimately connected with the *redundant matter accumulated round the equator*, or the *earth's equatorial protuberance*. Indeed, Sir John shows by a note, that a SPHERE would be perfectly indifferent to these retrograding influences.—AUTHOR.

Mrs. Somerville supplies the first evidence:—

"Some remarkable astronomical eras," that lady observes, "are determined by the position of the major axis of the solar ellipse, which depends upon the direct motion of the perigee, and the precession of the equinoxes conjointly, the annual motion of the one being 11″ 8′; and that of the other 50″ 1′. Hence the axis, moving at the rate of 61″ 9′ annually, accomplishes a tropical revolution in 20,984 years. It coincided with the line of the equinoxes 4,000 or 4,089 years before the Christian era, much about the time chronologists assign for the creation of man. In 6,483 the major axis will again coincide with the line of the equinoxes; but then the solar perigee will coincide with the equinox of autumn, whereas at the creation of man it coincided with the vernal equinox.*

"The variation in the position of the solar ellipse occasions corresponding changes in the length of the seasons. In its present position, spring is shorter than summer, and summer longer than winter; and while the solar perigee continues as it now is, between the solstice of winter and the equinox of spring, the period including spring and summer will be longer than that including autumn and winter. In this century the difference is between seven and eight days. The intervals will be equal towards the year 6483, when the perigee will coincide with the equinox of spring; but when it passes that point, the spring and autumn taken together, will be shorter than the period including the autumn and winter."†

Dr. Ure will furnish another testimony on this point:—

"The date of the earth's creation, according to the chronology of the Hebrew Bible, was 4,004 years before the birth of Christ. Astronomy shows that the great axis or longest diameter of the elliptic orbit, in which our earth revolves round the sun, as placed in one of the foci, coincided at that epoch with the line of the equinoxes. Hence, then, at the instant of the autumnal equinox, the sun was nearest the earth or in perigee, and of the vernal equinox he was in apogee; and therefore his elliptic orbit and time of revolution were each evenly divided between the seasons."‡

These interesting evidences must convince every one that *the precession of the equinoxes* is due to an excess in the retrograding influence of the sun and moon *on the redundant matter accumulated round the equatorial regions of the earth*, over and above a contrary effect, originating in a small secular motion of the ecliptic itself, caused by the action of the planets on one another, and on the sun, wholly independent of the figure of the earth. The increase of the precession being calculated from an epoch (usually the vernal equinox) when the longer axis of the solar ellipse, by coinciding with the equinoxes, occasioned a perfect equality in the moieties of the year; or, what is the same thing, when the precession was considered to have been 0—an astronomical event which,

* Mrs. Somerville having referred to the authority of chronologists, I subjoin the following from Blair's celebrated chronological tables:—"The creation of the world began, according to Archbishop Usher's calculations, on Sunday, the 23rd of *October*, in the year 4004 before the birth of Christ," a *season* which accords better than the other with the events which then occurred.—Author.

† Connexion of the Sciences, pp. 99, 100.

‡ Geology, p. 13.

according to the foregoing authorities, occurred about the period assigned in Scripture as that of the *formation of the light*, and its *division from the darkness*.

In a previous part of this section, I endeavoured to prove, and I trust satisfactorily, the following two positions:—

1. That during the period of darkness, the earth revolved around the unillumined sun for a sufficient length of time, in geological estimation, to form all the rocky masses which compose its outer crust, until the completion of the independent coal measures. And,

2. That the formation of the light, and its division from the darkness, were the immediate secondary causes of the earth's diurnal rotation; which, in turn, caused the protuberance of its equatorial regions, or the excess in the equatorial, beyond the polar diameter.

These two positions, and that established by the precession of the equinoxes, although proceeding from different sources, and different branches of science, are equally well authenticated, but require the adoption of one of the two following suppositions in order to be reconciled to one another, namely, either that the earth revolved around its axis, and assumed its oblate figure from the instant it was translated in space, and experienced precession of its equinoxes from the same period, in which case it is to be presumed, that the light was formed precisely as it completed a periodical revolution of 20,984 years; or, that during the period of darkness, when all the geological phenomena were forming, it had neither diurnal rotation, equatorial excess of diameter, nor secular retrogradation of its nodes on the ecliptic, but *that all these modifications took place on the formation of the light, and its division from the darkness.*

The adoption of the former of these two suppositions, involves the following insuperable difficulties:—

1. By imagining the diurnal motion to have taken place *before* the geological phenomena were produced, the only conceivable period for their proper formation is set aside, and the only known force, or power in nature, capable of having elevated the continental ridges and mountain chains. Consequently, the geological evidences are opposed to this assumption.

2. By supposing the earth to have had protuberant matter about the equator, *without* diurnal motion, there is involved, as a direct consequence, the destruction of the obliquity of the plane of the equator, to that of the ecliptic, as has just been learned from Professor Playfair's writings.* And,

3. By conceiving the earth to have revolved round its axis *before* the formation of the light, the only adequate effect which the formation of the light was calculated to produce is done away with, and a power of such magnitude as the introduction of the principle of expansion into the material universe is left, without having produced a corresponding effect, or without any effect at all.

* Playfair's Works, vol. ii. p. 412.

On the other hand, by adopting the conclusion come to by this theory, and admitting—what indeed can scarcely be denied—that the formation of the light and its division from the darkness, caused the rotation of the earth around its axis; that this, in turn, occasioned the terraqueous protuberance of the equatorial regions, and that the action, upon this, of the sun and moon, gave rise to the precession of the equinoxes; the latter phenomena will be found to have commenced *at the same moment as the formation of the light*, the point in *space* coinciding with the epoch in *time*, while a counteracting influence against the destruction of the obliquity of the two planes, will be found to exist in that which produced the secular disturbance; the whole manifesting the most perfect harmony between the announcements of Scripture, the laws of mechanics, the discoveries and calculations of astronomy, and the researches of geology; whereby it is clearly shown, that the equatorial protuberance of form; the preservation of the obliquity of the poles to the ecliptic; and the precession of the equinoxes have a common affinity to protorotation. And, that what are thus related physically and uranographically, date their origin from the same memorable period in time.

It appears, then, from all that has been said in these sections, *that the primary amorphous rocks arose from beneath and perforated the superincumbent stratified masses, or elevated these along with themselves, by means of the centrifugal impetus generated in them by the protorotation of the earth around its axis.* But as the earth could only have once commenced to revolve, and thereby have caused centrifugal impetus, all the rocks found thrust through, or elevating the strata, *must have been moved simultaneously.* Such being the case, there would be a period when the strata over the whole surface of the globe were horizontal, and parallel to each other; and a considerable lapse of time must have been required to have deposited them in successive layers, in the order of superposition in which they are generally found.

If, therefore, we keep the fact steadily in mind, *that the earth must have been for a long period without rotatory motion,* and blend it with what follows, derived from the first part of the *sixty-seventh* Theorem, which is equally well authenticated, namely, "*That one of the most important qualities of matter in mechanical investigations is* INERTIA, *or that property which results from its inability to produce in itself spontaneous change or action, either from a state of rest to that of motion, or vice versa, to diminish any motion which it may have received from an external cause, or to change its direction.*" Their dexterous combination will enable us to arrive at another very important deduction, namely—

That the earth, at one period, not having had rotatory motion; and consisting of inert matter, incapable of generating motion in itself, *a force sufficient to have overcome the resistance must have been*

brought to bear upon it from SOME SOURCE EXTERNAL TO, AND INDEPENDENT OF ITSELF, *before it could have revolved, as it now does, around its axis.* The inertia of the whole mass must have been overcome, before it could possibly have moved; before the geological phenomena, now displayed upon its surface, could have been produced!

This important conclusion reduces us to one of the greatest difficulties ever encountered by men who depend solely on their own resources, to assign *the* adequate cause which overcame the inertia of the world and made it revolve around its axis. *Science knows no such power.* It is only in the Sacred Volume that any allusion is made to the first rotation of the earth, "the evening and the morning were the first day:" an announcement which must not be looked upon as figurative, but understood in its plain, literal sense—a whole revolution of the earth around its axis in the space of twenty-four hours, or, what is the same, with an angular velocity of fifteen degrees each hour; for, unless this be admitted, and, likewise, that it was its *first* rotation, the necessary centrifugal force would not have been generated; the geological phenomena arising from that impetus would never have existed. So long, therefore, as a peak of granite is visible and tangible by the senses, may the finger be pointed to those monuments of Infinite power, and then to the emphatic announcement "the evening and the morning were the first day!"

SECTION VI.

METEOROLOGICAL PHENOMENA RESULTING FROM THE LIGHT, AND FROM THE EARTH'S PROTOROTATION.

CHAPTER XXIX.

Preliminary advertencies. The consequences likely to result from a world of water being thrown into violent agitation and motion by the first diurnal revolution. Longitudinal effects on it of the elevation of continental ridges, and the depression of oceanic hollows. The effects of the introduction of the principle of Expansion into the primeval water. Chemical analyses of water. No Nitrogen in water. No Hydrogen in the atmosphere. Nitrogen traced to its origin in ammoniacal gas. Chemical analyses of this alkaline substance. Free Oxygen—its source. Appropriateness of the juncture, while these elements abounded, for the introduction of Light into the material universe. Philological corroboration of these assumptions. The diffusion principle of gases requisite to complete the force which expanded the aerial elements to their prescribed boundaries. Meteorological phenomena. Composition of gases in general, and the indestructibility, in particular, of those which constitute the atmosphere.

At the close of the third section, the earth was considered to be revolving around the unillumined sun, but without diurnal motion, while its recumbent rocky crust sustained an equally diffused and universally spread mass of water; which, having undergone a purifying process through many ages, had been deprived of nearly the whole of its earthy and acidulous ingredients, and at the period to which I now allude, contained only saline materials, free oxygen and ammonia, which latter arose from the decomposition of animal substances, whose living possessors once inhabited infinite numbers of calcareous coverings discovered in the strata, and that the ammonia had assumed a supernatent position. It will, likewise, be recollected, that this was the state in which, in the subsequent section, it was supposed to have been, when it pleased the Creator to cause *the earth to rotate around its axis;* while I endeavoured, in that which followed, to unfold in succession the important results produced by that memorable and stupendous event upon its rocky masses.

In describing the effects which resulted from the movement of its aqueous portion, I confined myself almost exclusively to those which it exercised upon the broken fragments of the mineral crust, merely

investigating the results which occurred *underneath*, and were there occasioned by that singular movement of the water of the world. But equally important consequences took place in the upper regions of that watery mass, and in its lighter and more gaseous associates, which the comminution and agitation of the water permitted to escape, and, under the influence of the centrifugal impetus, to ascend, in vapourous expansion, into those vacant regions, whose full extent they were afterwards destined to occupy; and from whence, on this occasion, they did not return; but being there suspended by the wonder-working power of the Creator, were caused, by his immediate agency, to expand into the life-sustaining atmosphere; while their partial elevation, for that purpose, into space by a force so general, and so evidently destined for many other important purposes, as the centrifugal impetus occasioned by the earth's protorotation around its axis, affords another confirmation of the truth, that nothing is done in vain by the Omnipotent, but that every step in the process of this great work was previously designed by a plan of exceeding wisdom; and executed by infinite power.

Before endeavouring, by closer inspection into each successive step, to form a juster conception of this magnificent transformation, performed by the arch-chemist of nature, it will perhaps greatly aid our convictions were we to pause a moment, and imagine, if we can, the grandeur and sublimity of a world of atmosphereless water thrown into violent and uncontrolled agitation, silent and unattened by the slightest noise, in the absence of the vehicle of sound, but greatly augmented in motion by the successive elevation and depression of continental ridges and oceanic hollows, when "at his rebuke they fled, at the voice of his thunders they hasted away;" when they "went up by the mountains, and down by the valleys," or perhaps more correctly still, "when the mountains ascended, and the valleys descended."*

This may, perhaps, be the most opportune juncture for entering into some enquiries with a view to determine the relative levels maintained by the primitive water when the entire mass was thrown into motion by the first rotation of the earth around its axis, and before this was circumbounded by an atmosphere; and afterwards to endeavour to trace the line observed by "the firmament" when it "divided the waters from the waters," or, the level at which that expanse was introduced into the primitive ocean. These questions are not without their difficulties, but, to simplify them as much as possible, let the case be stated thus: A sphere, bearing upon its level surface an equally distributed atmosphereless mass of water of considerable depth, is caused to revolve around its axis with an angular velocity capable of elevating immense continental ridges and of depressing corresponding oceanic hollows, in lines running

* Psalm civ. 7, 8, and marginal reading.

nearly at right angles to the direction of the rotatory motion, and under these complicated conditions, it is required to know, *how the atmosphereless aqueous portion would be disposed of?*

The question naturally resolves itself into two separate branches. First. The manner in which the water would comport itself during the time when it was under the influence of the centrifugal impetus, and to a certain extent abstracted from that of gravity? and, secondly, How it would proceed after that impetus had ceased, and the water was restored to the influence of attraction, as far as liquidity admits of its operation?

With regard to the first of these divisions, it is obvious, that there would ensue consequences of a latitudinal, and consequences of a longitudinal character. With respect to the former, it has already been shown, in a previous part of this work, that the tendency of the water would be to rush from the poles towards the equatorial regions, in order to assume that state of equilibrium, or of rest, from which it had been roused; and which was necessary in order to complete the form of rotation; while, the difference or inferiority in the velocities of the higher latitudinal zones of water, as they swept towards the equator, by causing them to lag behind, and to acquire a westerly direction, would gradually transform the latitudinal effects into those of a longitudinal character.

Those of a longitudinal description are by no means so easily disposed of. They are attended by difficulties, greatly augmented by the paucity of evidence, or precedents to which reference might be made; and, therefore, adhering to that which is next best, I must abide by the light of the strictest analogy, and direct the attention steadily to the phases of the other phenomena which resulted from the proto-revolution of the earth around its axis, especially to those peculiar to its rocky strata, whose solid nature having bequeathed more permanent vestiges, afford surer data from whence conclusions may be drawn. The best way, therefore, will be, *to consider the water as the uppermost and most flexible of all the strata which constituted the exterior of the non-rotating earth.*

As the most prominent effects of the protorotation of the earth on its rocky masses was to abstract these, to a certain degree, from the influence of gravity, and thereby to cause them to recede from its centre; similar results would necessarily ensue with respect to the *water*, which, being held together by slighter cohesive attraction, would be more thoroughly comminuted, and consequently relieved to a commensurate extent from the pressure which all fluids sustain from their own body,* and, thus becoming less dense, would be better adapted for receiving the expansive influence which was so soon thereafter to be introduced into it. At the same time it should be remembered that when bodies of dissimilar densities capable of passing or permeating one another, are subjected to the same cen-

* According to the 90th Theorem and evidences.

trifugal impetus—if this be sufficient to overcome the inertia of the most ponderable—it will throw the heaviest further from the centre, even although it should have previously occupied a position nearer to the axis of gyration. Yet care must be taken not to apply this undeniable principle without due modification to the singular case under consideration, inasmuch as the compact nature and vast extent of area of the continents, and other eminences, evidently show, that as they could not pass through and change places with the water, they would unavoidably raise up upon their broad extent those parts of the circumfluent ocean which rested upon them, and thus, they would cause, during the prevalence of the elevating force, corresponding inequalities of surface on what had previously been one unbroken spherical sheet of tremulous water. As regards the longitudinal motion on the surface, it appears that a distinction should be clearly made, between that which remained at the original extent of surface, which by revolving with the revolving sphere, would partake of no other motion save that of rotation, whereas, the portion which was caused to ascend beyond those original bounds, by partaking of two motions, that of rotation, and that of ascent, would, according to the composition of forces, have a diagonal direction impressed upon it, in order that it might synchronously comply with both movements.

This is all I intend to say, at present, with respect to the motion which would take place in the upper or external surface of the primitive water by the first rotation of the earth around its axis. But there is still to be taken into account *that which was going on below;* for, during the same period, the rocky masses of the earth were undergoing mighty transformations; immense continental ridges were rising above the original level; and corresponding oceanic hollows were sinking beneath it; while we are warranted in supposing that similar results, modified only by the nature of the water, were taking place in it also to a certain extent. No one can imagine the continent of America, for example, to rise up from beneath a level plane of water, however deep it may have been above it, without causing a corresponding watery ridge or wave along the whole of its surface. And, in a corresponding manner, those portions of the primitive water which were perpendicular to where the depressions were made for the beds of the ocean, must have sunk along with that on which they rested; while the centrifugal impetus, being equal for all points on the same parallel of latitude, its longitudinal effects, in modifying these inequalities of surface, may be considered inappreciable. It is, therefore, presumed that matters would remain in this state during the whole of the first revolution which the earth performed around its axis: for it has been shown, that this was the period during which the rocky masses of the earth were elevated and moulded into their present diversity of form.

This brings me to the consideration of what was supposed to have taken place during the *second* day of the Mosaic week. Reference to the Record will show that the first command issued on that day—when the centrifugal impetus, impressed the day previous on the waters, is supposed to have reached its maximum—was "Let there be a firmament (or expansion) in the midst of the waters; and Let it divide the waters from the waters;" and when it is considered that the expansive force which caused the rotation of the earth, and had acted in a tangential direction, was now employed to stretch out the firmament, and that the lower plane of this must have cut the water near to where it is at present, we shall at once recognise the wisdom, which disposed the water of the primeval ocean to be raised into enormous longitudinal masses or waves, in order that the vaporization should be greater above the continental ridges, where it was so essential that the water should be evaporated, and not be *drained* off; while the same operation was comparatively trivial in and over those portions corresponding to the parts now forming our seas, where vaporization was not required; and when, in addition to this, it is considered that the shallowness and the increased temperature of the former—occasioned by the introduction into them of immense continents of heated mineral—would pre-dispose them to accelerated vaporization,* we shall have still greater cause to admire the providential care which directed the whole.

It becomes necessary now, to point the attention to a few preliminary explanations, which, although they may appear disconnected, will serve, nevertheless, to render the subsequent argument more continuous and uniform; and, besides, by storing the mind with these requisite notices, they will make what I have hereafter to bring forward more easily understood. Like the magnificent operation I am about to unfold, for which all the ingredients were anteriorly stored up, ready to be combined, to form the atmosphere —by our having a knowledge of these elements in the mind, the account of their subsequent harmonious combination, will be rendered more thoroughly convincing, and the grandeur and wonderful wisdom of the operation more readily and clearly perceived.

In conducting these succinct enquiries, my first care will be to explain the more intimate composition of water, and also the state of its elementary materials, when in combination.

Mr. Reid observes, "Water, it must be borne in mind, is a *true chemical compound*. It is not a mere mechanical mixture of elements, in the way in which air is a mixture of oxygen and nitrogen. A mere mixture of oxygen and hydrogen has not the properties of watery vapour, and before they can be made to form watery vapour they must be made to enter into chemical union by having a considerable degree of heat applied to them, or

* This is confirmed by a passage in Hutchinson's Principles of Meteorology, p. 27, et sequitur, and by another in the "Introduction to Meteorology," 1849, p. 98, et seq.

by being strongly compressed; none of which are at all necessary to cause a mere mixture of oxygen and nitrogen to have all the properties of air. There is a great *change* of properties, which is not the case with the oxygen and nitrogen of the air. When combined with the hydrogen into watery vapour, the oxygen has lost entirely its power of supporting combustion and respiration, although it is present in watery vapour in a far greater proportion than in air, and it is not easy to withdraw it from the hydrogen, being united by a strong chemical attraction; while the hydrogen has lost entirely its inflammability, and both have become so much altered that they are easily condensed into the liquid form, which cannot be done with either of them when separate; there is a change of bulk, for the quantity of vapour formed by a certain proportion of oxygen and hydrogen, occupies less space than the two gases separately; and heat and light are produced when they combine, a sure mark of chemical union. In this respect, water, as contrasted with air, forms a striking example of the difference between *combination* and *mixture*.

"It is also to be observed, that the water thus produced, is to be regarded *as a compound of hydrogen and oxygen, not of hydrogen and oxygen gases*."*

"Water," says Mr. Graham Hutchinson, "is composed of hydrogen and oxygen, the former being the strongest electro-positive, and the latter the strongest electro-negative element known."†

Mrs. Somerville confirms this when she says—

"Voltaic electricity is a powerful agent in chemical analyses. When transmitted through conducting fluids it separates them into their constituent parts, which it conveys in an invisible state through a considerable space or quantity of liquid to the poles, where they come into evidence. . . . . . Suppose a glass tube filled with very pure water, and corked at both ends; if one of the wires of an active voltaic battery be made to pass through one cork, and the other through the other cork into the water, so that the extremities of the two wires shall be opposite and about one quarter of an inch asunder, chemical action will immediately take place, and gas will continue to arise from the extremities of both wires till the water has vanished. If an electric spark be sent through the tube, the water will reappear. By arranging the experiment so as to have the gas given out by each wire separately, it is found that water consists of two volumes of hydrogen and one of oxygen. The hydrogen is given out at the positive wire of the battery, and the oxygen at the negative."

And in another part of the same work she thus expresses herself—

"The law of definite proportion, established by Dr. Dalton, on the principle that every compound body consists of a combination of atoms of its constituent parts, is of universal application, and is, in fact, one of the most important discoveries in physical science, ... in disclosing the relative weights of the ultimate atoms of matter. Thus, an atom of oxygen, uniting with an atom of hydrogen, forms the compound, *water;* but, as every drop of water, however small, consists of eight parts by weight of oxygen, and one part by weight of hydrogen, it follows, that an atom of oxygen is eight times heavier than an atom of hydrogen."‡

* Popular Chemistry, p. 101. † Principles of Meteorology, p. 160.
‡ Connexion of the Sciences, pp. 310, 311, 122.

"When water," says Dr. Thompson, "is pure, it is found to contain an equivalent of hydrogen, and one of oxygen, consequently, it is a chemical compound, whose atomic weight, in this country, is represented by 1—8.013=9.013, i. e. the combining proportions of these gases are in the ratio of 1 to 8.

"Its composition may be shown either by analysis or synthesis. By the former it is decomposed into its respective gases, in the relative weights mentioned, or by *volumes* into two of hydrogen and one of oxygen; by the latter it is produced when these gases are mixed in the proportions stated, and an electric spark transmitted. . . . . . . It is entirely neutral, having neither acid nor alkaline reaction."*

It will have been perceived, from what has now been transcribed, that water in itself contains no nitrogen; but, as this constitutes nearly four-fifths of atmospheric air, search will have to be made for this predominant ingredient in some one of the substances with which the primitive ocean was considered to have been saturated. Ammonia is partly composed of nitrogen, and taking it for granted, from what has been fully explained in previous parts of this theory, that *where* animal life abounded, and became extinct, *there* ammonia —one of the most copious exhalations arising from animal decomposition—must likewise have abounded; I shall go on to enquire into its composition, and the capability of water to become saturated with it to an almost unlimited extent.

"This alkali," says Dr. Murray, when treating of ammonia, "obtained by indirect processes, was known to the older chemists only in its combination with water, forming the liquid, which, from its volatility compared with the other alkalis, was denominated *volatile alkali*. Dr. Priestly first showed that a gas can be procured from this liquor by a moderate heat, and that the pure alkali is a permanently elastic fluid. It is therefore called ammonia, or ammoniacal gas, and its solution in water is called liquid ammonia.

"The proportions of nitrogen and hydrogen which form ammonia, according to very careful experiments made by Dr. Henry, are precisely *three* volumes of hydrogen and *one* volume of nitrogen, in conformity with the usual simple law of volumes. . . . . . Ammoniacal gas is largely and rapidly absorbed by water; the water, under a mean atmospheric pressure and temperature, taking up, according to Sir H. Davy, 670 times its bulk of gas. It is under the form of a watery solution that ammonia is usually employed as a chemical agent. . . . . It unites with all the acids forming neutral salts, which are all soluble and crystalizable, and have an acid taste, though they retain, in some degree, the properties of the base."†

"The substance called ammonia," Dr. Lardner observes, "was only known as a gas until a temperature of 46° was attained. Exposed to that temperature it became a liquid. Such a body, in high latitudes, would, at different seasons, exist in the different forms of liquid and gas; in winter it would be liquid, and at other seasons gas."‡

"A cubic inch of water," says Mr. Hugo Reid, "could absorb 670 cubic

* Introduction to Meteorology, 1849, pp. 132, 133

† Chemistry, vol ii. pp. 6—15.

‡ On Heat, Cab. Cyc., p. 178.

inches of ammoniacal gas. . . . . . By its property of absorbing gases, water is very useful to the chemist. For, by this means he can lay up a store of any gas, and preserve it for some time for use. . . . . . When water dissolves a gas, the bulk of the gas is frequently little, if at all altered, so that the two together occupy much less space than when separate; and hence the solution must be heavier than water. The reverse, however, is the case with ammoniacal gas; the specific gravity of water, which has absorbed as much as it can of this gas, is 0.875, that of water being 1000."*

"In volcanic countries," Mr. Donovan states, "a mineral is found which occurs in crystals, and in masses of a greyish, yellowish, or brownish, colour; its taste is sharp, burning, and saltish. . . . . . This is called *sal ammoniac;* it holds the alkaline gas in its substance; it is its base; and the alkaline gas has been named *ammonia*, or ammoniacal gas, from the salt which gives origin to it. Water absorbs upwards of 600 times its bulk of this gas, and acquires some of its properties; hence the compound is called *liquid ammonia*. During the absorption of ammoniacal gas by water, the liquid becomes hot; for the caloric which was latent in the gas, and maintained it as such, becomes sensible as soon as the gas changes its state to that of a liquid, according to a law already explained; hence the temperature rises. At the same time that the gas is thus absorbed, the solution suffers a permanent expansion, for the resulting liquid is specifically lighter."†

"According to Baron Liebig," says Dr. Thompson, "there is always present ammonia—composed of 1 volume of nitrogen, and 3 volumes of hydrogen, condensing into 2 volumes—derived from the decomposition of animal matters, from which gas the nitrogen of plants is supposed to be obtained. From the great affinity of ammonia for water, it will not be found *free* in a humid atmosphere. . . . . .

"According to Gieger, it exists in the atmosphere in combination with carbonic acid."‡

The existence of *free oxygen* in the primitive water is not very easily proved in a *direct* manner, although it can be effected by the soundest inferences. For as *water* was the only source from whence all those existences, which were generated in it, derived their gaseous elements, they, consequently, were mere modifications of that original element; while, as far as regards the present argument, it matters not through how many intermediate transitions they may have passed, provided they can be detected in any one whose proportional elemental ingredients differ from those of *water*.

This all-pervading element is composed of one volume of oxygen and two of hydrogen, in the relative proportions of 8 to 1 in weight; and as ammonia consists of three volumes of the latter, and one of nitrogen, it follows, that in the formation of this ingredient alone, which I have chosen for an example, the liberation of much oxygen can be accounted for. The same might be done with many other substances. Again, if without taking into account the great

* Popular Chemistry, p. 108. † Chemistry, in Cab. Cyc. pp. 112, 113.
‡ Introduction to Meteorology, 1849, p. 5.

proportion of hydrogen which enters into the composition of plants, we merely bring to mind their activity in decomposing carbonic acid, in order to fix the carbon, and *liberate the oxygen*;* and then consider the prevalence of submerged vegetable existences—now constituting the coal measures—which suddenly became buried beneath the debris (occasioned by the protorotation of the earth), and were thereby prevented from giving out the exhalations common to their decaying state—and reflect on the effects of the continued introduction into the water, from the previously decaying substances, of carbonic oxide and carburetted hydrogen, which would tend to keep the oxygen, thus liberated by all these agents, free from uniting with any other substance, or re-entering into spontaneous combinations without the aid of animal or vegetable secretion—it is presumed, that in these combined causes there will be found sufficient reason for admitting that towards the close of the non-rotating period of the earth's existence, its circumfluent water was abundantly saturated with *free oxygen*, whose presence, as has been shown, was so essential for the formation of the atmosphere, and for accelerating the oxydizing process in producing the soils, when the elevation of the continents and the separation of the land from the water took place.

Thus I have endeavoured, by these concise explanations, to trace the origin, and to show the existence, towards the close of the non-rotating period, of the requisite ingredients for the great work which was next to occupy the attention of the Creator—*the formation of the atmosphere*; while it is impossible to withhold admiration when we contemplate the perfect adaptation of the receptacle selected for storing up those ingredients, *an ubiquitous mass of water capable of retaining, and ready to give them out wherever and whenever required.*

It is always delightful to observe the fitness of means to the end, and the vastness of the scale on which the wonders of the creation were conducted; but the present affords more than the usual degree of gratification, from its attendant circumstances being so apparent, and more within the grasp of the intelligence. When aware of the design, it is at once perceived, that nowhere could a more adequate receptacle have been found in which to accumulate and to preserve the gases requisite to form the aerial ocean, which now floats around, than a mass of circumfluent and atmosphereless water, everywhere equally proximate to the space above them, which was destined to be filled by these subtile elements, in suitable proportions, when once they should be associated with the principle of expansion, to fit them for becoming *the life-sustaining atmosphere.*

Being fully persuaded of these sublime truths, and having present to the mind the state of elevation and dispersion in which the primeval water was maintained by the centrifugal impetus, under

* Botany, by Professor Henslow, Cab. Cyc.

whose dominion it is considered to have been at this epoch, whilst the physical light had just been introduced into the universe, the record of Scripture giving the next command of the Creator is most appropriate—namely, "Let there be a firmament in the midst of the waters, and Let it divide the waters from the waters."

All who reflect maturely on what has now been stated, will acknowledge, that this was the juncture most consistent with infinite wisdom for effecting the permanent alliance between the radicle of the gases accumulated in the water, and the expansive principle with which they are combined, and which transformed them into aerial gases. Whether the ocean was saturated, as supposed, with free oxygen, or whether the water itself was decomposed to supply it, does not in any way affect the appropriateness of the *period* chosen for transforming those radicles into gaseous elements; the mass of water was then maintained by the influence of the centrifugal impetus, high above the land and its present level; and, at the same time, its elements were dispersed and more easily penetrated by the light, which conferred on them their permanently elastic state; and, therefore, the fact of this being the juncture recorded in Scripture, for the formation of the atmosphere—whether from elements in or associated with the primeval water—when it was under the influence of a centrifugal force of such power as that engendered by the first rotation of the earth—stamps the impress of truth on the passage, and assures us in language which can neither be mistaken nor set aside, that infinite wisdom planned and executed the whole.

Before proceeding to investigate more minutely into this subject, scientifically, let us attend to a few general observations to prepare the mind, and to show the extreme difficulty of the field of research on which we are now about to enter. In whatever manner the principle of heat and light may have been combined with the gaseous bases, so as to fit them for becoming the components of the atmosphere, one thing seems perfectly obvious, namely, *that during the execution of the operation in question, there must have been an ascent or movement upwards of the molecules of matter*; for neither the water nor its elements could have been raised by *the centrifugal impetus* to the height of 40 or 50 miles above the earth's surface, to which the upper limits of the atmosphere now extend. Therefore, there must have been a movement of matter *upwards*, or contrary to the direction of gravity, until the elements of the atmosphere reached their destined limits. This general truth is in itself undeniable, and may probably be referred to again during the course of the argument.

With respect to the difficulties attending the study of this subject—even when the investigation has reference to an atmosphere *already formed*—they are so well, and so appropriately expressed by an eminent writer on the subject, that no apology need be offered for using his own language:—

"The real state of things," says Professor Whewell, when treating of the watery vapour, "which we enjoy, the steam being mixed in our breath and in our sky in a moderate quantity, gives rise to results very different from those which have been described. The machinery by which these results are produced is not a little curious. It is, in fact, the machinery of the *weather*, and, therefore, the reader will not be surprised to find it both complex and apparently uncertain in its working. At the same time some of the general principles which govern it seem now to be pretty well made out, and they offer no small evidence of beneficent arrangement."*

And again—

"The varying occurrences thus produced, tend to multiply and extend their own variety. The ascending streams of vapour carry with them that *latent heat* belonging to their gaseous state, which, when they are condensed, they give out as sensible heat. They thus raise the temperature of the upper regions of air, and occasion changes in the pressure and motion of its currents. The clouds, again, by shading the surface of the earth from the sun, diminish the evaporation by which their own substance is supplied, and the heating effects by which currents are caused. Even the mere mechanical effects of the currents of fluid on the distribution of its own pressure, and the dynamical conditions of its motion, are in a high degree abstruse in their principles and complex in their results. It need not be wondered, therefore, if the study of this subject is very difficult and entangled, and our knowledge, after all, very imperfect."†

And a more recent and no less intelligent writer has the following apposite transcriptions which, with his guarantee attached to them, we adopt as additional evidence:—

"Never," says Arago, "whatever may be the progress of the sciences, will the *savant* who is conscientious and careful of his reputation, speculate on a prediction of the weather."

And, once more, to quote the eloquent words of Sir David Brewster—

"In the very atmosphere in which he lives and breathes, and the phenomena which he daily sees and feels, and describes and measures, the philosopher stands in acknowledged ignorance of the laws which govern it. He has ascertained, indeed, its extent, its weight, and its composition, but though he has mastered the law of heat and moisture, and studied the electrical agencies which influence its condition, he cannot predict, or even approximate to a prediction, whether, on the morrow, the sun shall shine, or the rain fall, or the wind blow, or the lightnings descend. 'The wind bloweth where it listeth, and thou hearest the sound thereof, but canst not tell whence it cometh or whither it goeth.'"‡

If the study of the machinery of the weather, when contemplated in an atmosphere already formed, appears so arduous, what must be the difficulties of any one who undertakes to explain its original formation?

To proceed with this enterprise, however, difficult as it may be,

* Bridgewater Treatise, p. 98. † Ibid, pp. 103, 104.
‡ Introduction to Meteorology, by Dr. Thomson, pp. 439, 440.

let us now learn the nature of the Atmosphere itself, as revealed to us by experimental philosophy.

The *eighty-fourth* Theorem states, "*That the* ATMOSPHERE *is an aerial ocean surrounding the earth in all directions, and of which the surface of the land and sea forms the bed. That its density diminishes with extreme rapidity as it proceeds upwards; and, eventually, at a height not exceeding fifty miles, reaches a real and definite boundary. That this upper surface is estimated to be precisely where the specific elasticity of the air is balanced by the power of gravitation. And, that the mean temperature of space is considered to be* 58° *below the zero point of Fahrenheit.*"

The truths contained in the Theorem which has been recapitulated, are of so rudimentary a character that they require no confirmation. I shall, therefore, go on to give the information contained in that which immediately follows:—

"*That the* ATMOSPHERE *is composed of aerial fluids, chiefly oxygen and nitrogen, in the ratio of one volume of the former to four of the latter; or, more correctly, one hundred parts of atmospheric air contain* 20 2-10*ths of oxygen and* 79 2-10*ths of nitrogen. It also contains variable quantities of carbonic acid gas and of aqueous vapour. That the two first of these have never either been liquidized or rendered incandescent; while the amount of moisture varies according to the dew point and state of the barometer. That although in certain states it is* 815 *times lighter than water, it exerts a pressure on the surface of the earth equal to* 15*lbs. for every square inch: a pressure which prevents the sun's rays from converting water and all other fluids into vapour. That it is permanently elastic, its tension increasing in proportion to its density; admits of considerable variation in the quantity of its associated watery vapour; and, that a gas and a vapour, occupying the same space, have a tension equal to their combined tensions.*"

Having acquired this requisite information, let it be conceived, that, through the effects of the centrifugal impetus, the water was considerably dispersed, and its associated elements separated into minute particles of oxygen and liquid ammonia; and, that at this very juncture, the command "Let there be a firmament (or expansion) in the midst of the waters," was given, and then endeavour to follow up the consequences of light, heat, or electricity—the principle of expansion—having been combined with the elemental ingredients thus put into violent agitation.*

Perhaps the most perspicuous manner of treating the subject will

* I have been confirmed in this view by the following paragraph with which Dr. Thomson concludes his recent and excellent volume on Meteorology, published years after the above was written:—

"The various meteors described," says he, "are not the offspring of separate causations, but functions of common principles. The intimate agency of heat and electricity is apparent in the *tout ensemble* of the science. The former is the *primum mobile* of Meteorology, and oxygen, nitrogen, and hydrogen are the elements on which it operates." (Introduction to Meteorology, 1849, p. 440.)

be to consider it in separate parts. To take up, first, the aerial portion of the atmosphere, apart from its aqueous associate, and endeavour to trace its formation by the union of light with the elements of which atmospheric air is composed. And, in continuation, to consider, that the same expansive principle was subsequently made to combine with water, so as to constitute the aqueous or vapourous portion of the great aerial ocean which now floats around us, sustaining life, and imparting vigour to all within its influence.

Closing in by degrees from these more general conceptions, we must bring to mind, *that the air has no hydrogen in its composition, and that water has no nitrogen, while no process is known whereby the one can be transformed into the other*. This will simplify the question very much; it will enable us to eliminate the hydrogen of the water entirely from our attention when considering the constitution of the atmosphere itself; and constrain us to restrict our researches for the required nitrogen or azote entirely to the ammonia, with which the primitive water is supposed to have been so abundantly saturated towards the close of the non-rotatory period.

When it is considered that "water can absorb 670 times its own bulk of ammoniacal gas," and that the relative density of the atmosphere, when compared with the oceanic water, may be estimated by the fact, that the former exerts a pressure on the surface of the globe, as if it were enveloped with water only to the height of 34 feet above the surface;* these assumptions will be found quite consistent with the nature of all the elements supposed to have been then present.

Expansion, or the expansive principle, is assumed to emanate from, or to be a diversified manifestation of light and heat. These, in turn, are considered to be identical with electricity, and capable of being made to produce, under certain circumstances, similar effects.† But whether this principle be designated by the name of light, heat, electricity, or expansion, one thing regarding it, as far as the present argument is concerned, is alike certain—*that it came from some source altogether beyond, and, therefore, wholly independent of the water*. The announcement is quite special with regard to this, and would not have been made had the expansive principle previously existed there. "Let there be expansion in the midst of the waters," is the clear and specific command. Therefore, we must conclude that it came from some exterior source. And, consequently, on reaching the water from without, whether it acted as a tangential, or as a direct force, it must, according to the regular order of causes, *have come first into contact with the uppermost strata of the water*.

* Reid's Popular Chemistry, p. 31, and Dr. Thomson, p. 444.

† Theorems 64 and 74, to which please refer. Also to Thomson's Meteorology, p. 278.

Even should it be deemed superfluous, it cannot be too frequently repeated, that we are treating of a period when the light was not, as it is now, imparted "in measured quantities according to the angular velocity with which the earth passes round the sun" *(second Theorem)*, but that this subtile fluid was being made use of as a material *primum mobile* to complete the work in which the Creator was engaged; and was being imparted to the several previously prepared materials, in the way, and to the extent which was most accordant with the completion of that work.

The uppermost portion of the primeval water was, as has been shown, abundantly saturated with free oxygen and ammonia; and, mark what follows: it is asserted by an eminent practical chemist, "that on the introduction of electricity into ammonia, where oxygen is likewise present, *water is formed, and nitrogen is liberated.*"* Thus, by being made aware of the appropriate arrangement of these elements in the great laboratory of nature, and of the introduction amongst them of the principle of expansion, we behold with admiration and gratitude, the purpose for which it pleased the benignant Creator to prepare a reservoir of nitrogen, sufficient to form four-fifths of the whole atmosphere, that the oxygen which was in due time to be added to it, might be diluted for the respiration of myriads of creatures then as yet unborn; and also the manner, no less simple and elegant, by which the oxygen destined to complete the elements of the atmosphere, was liberated from the fluid in which it had been stored up. For it is asserted by a French chemist, as the result of one of his operations, that on *applying heat to a quantity of water impregnated with a double volume of oxygen, the super-proportional oxygen is driven off, while the water itself remains in its original state.* This reveals another of the designs for which heated mineral masses, composing the continents of the earth, were introduced into an ocean surcharged with the oxygenous elements of a world's atmosphere!

The contemplation of such mighty operations, conducted with so much wisdom, must afford to an unprejudiced mind the most exquisite satisfaction and delight. And, when we add to these the consideration of the facts, that an agent so subtile and whose effects are so soft and impalpable as light, was made use of; and that a body so admirably adapted as water for receiving, without transmitting the effects of the percussion, was caused to intervene between the impulse and the terraine portions of the earth, the entire arrangement affords a perfect illustration of the surpassing wisdom which designed and executed the whole.

But there are still to be traced the more permanent effects of the introduction of the expansive principle into the water of the primeval ocean. Its first results have just been made manifest; I shall now endeavour to show how these gaseous bases were transformed into

* Dr. Ure's Chemical Dictionary, p. 151.

the elements of an aeriform fluid so pre-eminently elastic as the atmosphere. With this design, whatever evidences are afforded by the researches and the discoveries of chemists will be availed of; while it may heighten our admiration to reflect, that previous to the formation of the atmosphere itself, the combining power of light and heat would be considerably augmented:* that is, the power, or the combining influence of light would be by an entire atmosphere, greater than what the rays of light can now exercise in uniting with, or in conferring their effects upon any substance which they may be employed to transform under the existing pressure of the atmosphere.

The *eighty-sixth* Theorem states, "*That every gas has, at least, two ingredients in its composition, namely, some gravitating matter, which may be called its base or principal part, and the subtile fluid, caloric or heat, and perhaps light and electricity; which, when present in sufficient quantity, cause the base or radicle to appear in a gaseous form.*" The following are some of its evidences:—

"Bodies," observes Dr. Lardner, "existing in the aeriform state, are divided into two classes, called *vapours* and *gases*. . . . . . The latter are those aeriform bodies which have never been known to exist in any other than the aeriform state, and which, under all ordinary degrees of cold, preserve their elastic condition. This class includes common air, and a great number of substances known in chemistry under a variety of names, but all comprised under the general denomination of *gases*. . . . . . Such bodies would maintain all the gaseous qualities which they are observed to possess at present, though they may be capable of being condensed, and even solidified, if we possessed practical means of depriving them of a sufficient quantity of heat which they contain. For, in proportion as more powerful means of extorting heat from gases has been invented, a greater number of them have been forced within the limits of the law of condensation. . . . . .

"Since it is certain, that *gases* may lose a considerable quantity of heat, without undergoing any degree of condensation, we must look upon them as vapours; which, besides the sum of the latent and sensible heat necessary to sustain them in the elastic form, have, subsequently to attaining that form, received a large accession of heat; and yet, from their nature, with all this supply of heat, their temperature does not exceed the ordinary temperature of the globe."†

Although the following evidence, on the same point, is abstracted from a part of Mr. Donovan's treatise, in which he endeavours to controvert the Lavoisierian theory of combustion, it nevertheless corroborates what is sought at present to be established, and shows, very manifestly, the opinion of the celebrated French chemist, with respect to the composition of gases:—

"One of the most remarkable, important, and least understood phenomena

* No less than 124° of Fahrenheit's thermometer. And, according to Robinson, fluids boil in vacuo at 140° lower than in the open air.—(Thomson, p. 18).

† Heat, in Cab. Cyc. pp. 177, 178.

in nature," says Mr. Donovan, "is the process of combustion. It has unsuccessfully occupied the attention of philosophers in all ages; and, even at this moment, the chief difficulty remains unexplained. . . . . . The theory which, of late years, has occupied most attention, is that of Lavoisier."

After going somewhat into particulars, and referring to the early announcements of Dr. Robert Hooke, he goes on to state,

"According to Lavoisier, combustion can never take place but when oxygen is present. *Oxygen gas is considered by Lavoisier to be a compound of a gravitating base, with caloric and light.* When a combustible substance is exposed to the necessary temperature in oxygen gas, the latter is decomposed, the gravitating basis of the gas combines with the combustible, and the heat and light separate from the gas in the form of fire. . . . . . He attributed to oxygen gas a greater quantity of latent heat than to any other. A different explanation of the source of the supply of heat was soon, however, found necessary. . . . . .

Mr. Donovan then gives the reasons for this, and proceeds—

"A modified theory was then proposed. *Oxygen* GAS *consists of oxygen* (as the gravitating base was called) *combined with caloric.* Combustibles consist of an unknown base; combined with light, in combustion a double decomposition takes place; the oxygen gas gives up its heat, and the combustible its light; the heat and light combine and form fire, while the oxygen and combustible base form the new product."* And so forth.

"It is also to be observed," says Mr. H. Reid, "that the WATER thus produced is to be regarded *as a compound of hydrogen and oxygen, not of hydrogen and oxygen gases.* These gases consist each of some unknown matter in union with heat, and, perhaps, light and electricity; and, as Dr. Henry observes, if we could divest them of these, they would probably appear in the solid or liquid form; but hydrogen and oxygen gases have never been condensed into the liquid form, no pressure that has been hitherto applied to them, and no degree of cold to which they have ever been subjected, being capable of producing this effect. We apply the term 'oxygen' to that matter, for example, which, united with the iron in the gun-barrel, had assumed the solid form; that was, evidently, not oxygen *gas.* In like manner, the term hydrogen is applied to that matter which exists in union with oxygen in water, evidently not hydrogen *gas.* Every gas has, at least, two ingredients in its composition, namely, some gravitating matter, which may be called its base or principal part, and the subtile fluid caloric or heat, which, when present in sufficient quantity, causes this base to appear in the gaseous form. . . . . It is considered, therefore, that oxygen and hydrogen gases consist of some unknown bodies called oxygen and hydrogen, in union with a considerable quantity of heat. This heat is not apparent to our senses, does not make the oxygen and hydrogen feel warm, is not heat in the common meaning of the term: but it is, nevertheless, clear that they must contain it, or the principle which causes heat, for they produce it when they combine chemically, and produce a very large quantity of it. This heat was in them in a concealed or hidden state, but it has the effect of retaining them in the gaseous condition with great force, and, indeed, ren-

* Chemistry, in Cab. Cyc. pp. 350—352.

dering it impossible for them to be condensed into liquids. . . . . . Oxygen and hydrogen gases, then, consist of oxygen and hydrogen united to a great quantity of heat."*

Having thus been made aware, in the most convincing manner, that gases are essentially composed of a gravitating base, in union with a subtile, self-expansive imponderable fluid; I shall proceed to exhibit the fruitlessness of all attempts to separate between the expansive principle and the bases of the elements of the atmosphere. The remarkable and pointed testimony, which is unconsciously afforded by chemical research to the truth of this is embodied in the *fifty-fifth* Theorem, wherein it is stated, "*That oxygen, nitrogen, and hydrogen gases have been severally submitted, by the first chemists of the age, to the enormous pressure of eight hundred atmospheres, without their having succeeded in reducing either of them to the liquid state; although many other gases have been liquidized by their vigorous and well-directed exertions.*" And again, in the *eighty-fifth* Theorem, it is asserted—*That the elements of the atmosphere have never been either liquidized or rendered incandescent.*"

"All substances," it is said in the *Connexion of the Sciences*, "may be compressed by a sufficient force, and are said to be more or less elastic, according to the facility with which they regain their bulk or volume when the pressure is removed, a property which depends upon the repulsive force of their particles. But the pressure may be so great as to bring the particles within the sphere of the cohesive force, and then an aeriform fluid may become a liquid, and a liquid a solid. Dr. Faraday has reduced some of the gases to a liquid state by very great compression; but although atmospheric air is capable of a diminution of volume, to which we do not know the limit, it has hitherto always retained its gaseous properties, and reserves its primitive volume the instant the pressure is removed."†

Dr. Thomson says—

"The atmosphere is composed of aerial fluids, chiefly oxygen and nitrogen, in the ratio of one volume of the former to four of the latter. Such is the result of numerous analyses. . . . . . The subject of the equable mixture of these gases is one of much difficulty, and as yet resting on probabilities. The atmosphere has hitherto resisted every effort to produce its liquifaction.

"Let us digress and examine the properties of these gases. They are elastic fluids, clear, colourless, devoid of smell and taste, but no further do they agree.

"*Oxygen* is heavier than air, its specific gravity being as 1.111 to 1.000, It is a supporter of combustion, and is the most powerful negative electric known; consequently always appears at the positive electrode. This gas has resisted the efforts of chemists to liquify it, though subjected to the pressure of 585 atmospheres, at the temperature of 145° Fahrenheit. Without oxygen life could not be sustained. In it, unmixed with other gas, life flits away with greater rapidity than in common air. It is the most abundant of all elements. It is met with in every rock, rock-salt excepted; in

* Chemistry, by Hugo Reid, pp. 101, 102. † Connexion of the Sciences, p. 119.

water it forms 89 per cent., and it is an essential constituent in all organic bodies. It has been computed to constitute one-third of the weight of the whole globe.

"*Nitrogen* or *Azote* was first observed by Rutherford, of Edinburgh, in 1772. It is lighter than atmospheric air in the proportion of 0.9727 to 1.0. It neither supports combustion nor does it sustain life, though it performs a most important part in its economy. . . . . .

"These gases are not met with in nature *free*, with the single exception of the air volcanoes of Turbaco in South America, which give off nitrogen. To these ingredients of the Atmosphere Orfila adds electricity, light and caloric necessary for suspending the substances in the gaseous state."*

"The results of experimental enquiry," writes Dr. Lardner, in the Cabinet Cyclopædia, "justify us in assuming, as a universal law, that by the application of a sufficient quantity of heat, all solids may be converted into liquids; and by the abstraction of a corresponding quantity of heat, all liquids may be converted into solids. We have likewise seen, that by the supply of heat in sufficient quantities, all liquids may be converted into the vaporous or gaseous form; and analogy would lead us to infer, that, by the due abstraction of heat, the bodies that exist in the gaseous form might be reduced to liquids. The practical results here, however, fall short of the anticipations to which analogy leads us. There is a numerous class of bodies existing in the gaseous form, among which atmospheric air may be mentioned as the most obvious, which no means hitherto known have converted into liquids. . . . . . If a permanent gas be submitted to severe mechanical compression, its temperature will be raised, and the heat which it contains may be more easily withdrawn from it, and imparted to freezing mixtures, or extracted by any of the usual means of exposing it to extremely low temperatures. By continually carrying on the process of compression, additional quantities of heat may be developed and withdrawn, so that at length we may succeed in reducing the quantity of heat contained in the gas to that sum of latent and sensible heat, which seems the limit of the quantity necessary to maintain the elastic form. Any further reduction would be necessarily followed by condensation.

"Means similar to these have, accordingly, been applied, and succeeded, in the hands of Dr. Faraday. . . . . . In this way, nine gases were condensed into the liquid form.

"Dr. Faraday attempted, without success, the condensation of various other gases by the same means. Oxygen, azote, and hydrogen have, it is said, been submitted to a pressure of eight hundred atmospheres, without passing into the liquid state."†

* Introduction to Meteorology, 1849, pp. 3, 6—9.
† Heat, in Cab. Cyc. pp. 177—179.

SECTION VI.

METEOROLOGICAL PHENOMENA RESULTING FROM THE LIGHT, AND FROM THE EARTH'S PROTOROTATION.

CHAPTER XXX.

Allusion to the concluding subject of the foregoing chapter. Diffusion principle of Gases. Theorem and scientific evidences in favour of their expansiveness. Scriptural corroborations. The Atmosphere. Its aerial portion. Its aqueous or vaporous portion. The action of these two distinct bodies on one another, constituting the principal part of the machinery of the weather. Recapitulation of these points, and their application to elucidate the Dynamical Theory.

The investigations which were entered into in the preceding chapter, have shown, that the gaseous elements of the atmosphere consist of a base or radicle in union with the *expansive* principle, in so intimate a manner, that no means or power which the most scientific chemists have hitherto been enabled to bring to bear upon them, although a pressure equal to 800 atmospheres was applied, have been found sufficient to separate these associates. But we have yet to learn the more surprising fact, that, in a manner analogous to that in which each of these imperceptible particles may be supposed to be enveloped in a coating, or hollow sphere of expansion, their aggregate effect seems designed to produce a proportionably extended atmosphere, which surrounds the whole globe, with properties so peculiar as to indicate its almost abstraction from the otherwise universal law of gravity; for its elements expand by a law peculiar to themselves—termed "the *diffusion* principle"—into regions transcending the earth's surface by forty-five or fifty miles; although, strange to add, as a *collective* body this hollow sphere of aerial fluid possesses considerable gravity, pressing upon the surface with a force, as already mentioned, of fifteen pounds for every square inch.

As the singular property of diffusion is that which more immediately interests us at present, it will be attended to exclusively. Meanwhile, as this peculiar principle has only lately been discovered, the notices respecting it will not be so full as could otherwise

have been wished. The *eighty-seventh* Theorem has reference to it, and states, "*That with respect to the oxygen and nitrogen gases of the air, although the expansive principle acts powerfully in repelling from each other the particles of the same gas, it does not act between those of different gases. That by the 'diffusion principle of gases,' when two are put together they will finally be arranged as if each occupied the whole space and the other was not present; the heavier being caused to ascend, and the lighter to descend. That this is the case with the gases of the atmosphere, and that there seems to exist a power acting upon permanent gases capable of counteracting, to a certain extent, the effects of the attraction of gravitation, and thereby forming an exception to what has hitherto been considered an universal law.*"

The following evidences corroborate these truths :—

"Strange as it may appear," says Mr. Reid, "it is now the general opinion among chemists, that *the oxygen and nitrogen of the air are not in chemical union with each other, but that they are merely in a state of mechanical mixture.* . . . . . There are some reasons which might lead us to regard the oxygen and nitrogen of the air as existing in chemical union with each other. Oxygen and nitrogen, it is known, have a strong chemical attraction for each other, and are disposed to combine; the oxygen is heavier than the nitrogen, and if they are not in chemical union together, we should suppose that the oxygen would sink to the ground by itself, and the nitrogen float above it, like oil upon water; but this is not the case, for they are mixed in the same proportions at whatever distance from the ground, as Guy Lussac found in air which he collected at an elevation of nearly 22,000 feet, having ascended to that height in a balloon; also oxygen and nitrogen are present in the atmosphere exactly in the same proportions, estimated both by weight and by measure, in which, from the laws of chemical combination, it is known they would be united, if it were a chemical union. But nevertheless, they are regarded as being merely mechanically mixed, not chemically combined; for, there is no change of form (to the solid or liquid state) as happens frequently when gases combine chemically; there is no diminution in bulk, another frequent effect of chemical union, the two gases occupying separately the same bulk as they do when forming air; generally, in effecting chemical combinations, something more is required than merely bringing the materials in contact with each other, as light, heat, or mechanical condensation, and it is well known, that gases do not combine readily on being merely mixed; but the proper proportions of oxygen and nitrogen, if merely mixed well with each other, form a gas having all the properties of air; the refractive power of the air is exactly what would be expected in a *mixture* of oxygen and nitrogen; there is no *alteration* of properties, merely a *weakening,* for the oxygen presents the same properties as in the uncombined state, only diminished in energy from the large quantity of nitrogen present; and, lastly, there seems to be no affinity (at least a very weak one) binding the oxygen and nitrogen to each other, for the oxygen is abstracted with great ease by any substance which has an attraction for it, the nitrogen appearing to exert little or no force in retaining it. Water has the power of absorbing oxygen, though the attraction is not very great between them; yet even this weak affinity separates

the oxygen from the nitrogen, for rain water contains a very large quantity of oxygen. Such are the leading arguments which may be adduced to show that the oxygen and nitrogen of the air are in a state of mechanical mixture, not chemically united.

"Some interesting experiments, by Dr. Dalton, of Manchester, showed that besides chemical attraction, there is another power in existence which would cause the two gases to remain mixed with each other, and which would overcome the power of gravitation of the heavy one, which would tend to separate them. Dr. Dalton made various experiments with different gases, amongst which were oxygen and nitrogen, and found, uniformly, the results to be, as he expressed in the following words: 'It appears to me as completely demonstrated as any physical principle, that whenever two or more such gases or vapours are put together into a limited or unlimited space, they will finally be arranged each as if it occupied the whole space, and the others were not present.' That is, each will be diffused or spread out through the whole space, not separating according to their respective specific gravities. This intimate intermixture of the two gases cannot be attributed to chemical attraction, for there is no chemical affinity subsisting between carbonic acid and hydrogen; it must be dependent on some other power, which, acting between gases so different in density as carbonic acid and hydrogen, causing the heavy one to ascend and the light one to descend, will produce the same effects with the oxygen and the nitrogen in the air. It is now generally considered, that it is in obedience to this law, that the oxygen and the nitrogen are mixed in the air in the same proportion everywhere. Dr. Dalton supposes, that though the repulsive principle acts powerfully in repelling from each other the particles of the same gas, it does not act between those of different gases; that, therefore, a gas, by the elasticity of its particles, expands into any space to which it may have access, completely disregarding any other gas which may be in that space, while the gas previously there acts in the same way, and they thus become mutually diffused through each other.

"Mr. Graham, of Glasgow, found that this expansive tendency in each gas is so great, that the intermixture takes place even when the two gases are separated by some substance of a porous nature, as plaster of Paris, bladder, cork, or stoneware. It has been named the 'Diffusion of Gases,' and is an extremely curious and interesting subject, throwing light on many natural phenomena, and bringing to view a power formerly quite unknown, and capable of producing effects, which, from our previous knowledge of the laws of nature, we would have been apt to pronounce as impossible. . . . . .

"Indeed, such are the facts brought to light by Mr. Graham's experiments, that although our knowledge of the diffusion principle may be considered as yet in its infancy, they evince the existence of a power acting upon gases, and capable of counteracting, to a certain extent, the effects of the attraction of gravitation, forming an exception to what was formerly considered a universal law; and much may be expected from the progressive development of this singular law of the Diffusion of Gases."*

"The aqueous particles," says Dr. Ure, "are not suspended in the atmosphere by any power analogous to that of chemical solution. There is merely a mechanical mixture of particles in juxta-position, a state which

* Popular Chemistry, pp. 76—81.

most probably represents the mixture of oxygen, azote, and carbonic acid in the permanent atmosphere."

"In viewing the atmosphere," continues Dr. Ure, "as consisting of oxygen and azote, we cannot help remarking the delicate equilibrium of chemical proportions on which the well-being of organic life, and even the whole aspect of nature depend.

"Were the proportion of oxygen or vital air diminished, breathing would be laborious, every warm-blooded animal would become asthmatic, and coal would not cheer the domestic hearth. On the other hand, were the proportion of the vital ingredient doubled, that is, instead of one of it to four of azote, as at present, were there two to four, the temperate breath of heaven might suddenly change into an atmosphere of intoxicating gas; for these are the chemical proportions and sole constituents of this curious air. Were the bulk of oxygen quadrupled, so that its quantity should equal that of azote, a most noxious air called nitrous gas (dentoxide of azote) might result; a gas which, with an additional charge of oxygen, would condense into an ocean of aqua fortis, or nitric acid. A slight modification of chemical affinity, would convert even our existing atmosphere into the most corrosive of liquids; a result which the Hon. Mr. Cavendish many years ago produced, by merely transmitting electric explosions through a small portion of common air. But science shows that the chemical equilibrium of the atmospheric elements is fixed by the same beneficent wisdom which confines the turbulent ocean, by an apparently slender barrier of sand."*

Mr. Daniel has the following just remarks on this curious subject:

"The constancy of the proportions, in which the gases of the atmosphere are found to be combined in every situation, notwithstanding perpetual causes of disturbance, is the never-failing theme of wonder. If we suppose a consumption of the oxygen to take place, by the decomposition of the oxygen and carbonic acid added, as in the process of combustion, at any given spot, in what way is chemical affinity to act, so as to restore the uniformity of the compound? No new evolution of oxygen takes place, and it cannot be supplied by the contiguous portions, for we can never suppose the affinity of azote for oxygen to be satisfied, by the decomposition of an adjoining mass of azote and oxygen, held together by the same affinity. But if the oxygen and azote be two distinct elastic atmospheres, as Mr. Dalton originally suggested, mutually permeating one another's interstices, the particles of each pressing only upon their fellows, and offering slight obstacles to the motions of the other sort; then a partial consumption of oxygen would be instantly supplied by a rush of the elastic fluid towards the spot where the equality of the pressure had been disturbed. In fact, no sooner does a particle of oxygen quit the azote and enter into a new combination, than the rows of particles by which it was pressed all around, speedily supply its place. The same reasoning may be applied to carbonic acid, so profusely generated in combustion and respiration; for, if not rapidly dispersed, a city would be uninhabitable in still weather."†

Dr. Thomson says—

"The proportion of oxygen and nitrogen in the atmosphere is the same on the tops of mountains and in the most sheltered valleys. . . . . .

"From every recorded analysis of air," he continues, "*Uniformity has*"

* Ure, pp. 53, 54. † Ibid, pp. 65, 66.

invariably "*resulted*. . . . . . The equable mixture of these gases, though of dissimilar specific gravities, has been ascribed to the principle of resistance of the particles of the same gaseous fluid.

"Let us suppose with some, that atmospheric air is a *chemical* compound, or grant, with the late Dr. Dalton, that the gases are merely *mechanically blended*, we cannot too much admire the wisdom of the Creator in adjusting the proportions so exactly for the comfort and preservation of his creatures. Two volumes of nitrogen and half a volume of oxygen compose the air we breathe. *Two* volumes of nitrogen and *one* volume of oxygen form nitrous oxide, a fluid which would be fatal if breathed for any length of time. *Two* volumes of nitrogen and *two* volumes of oxygen form nitric oxide, a gas which cannot be respired. *Two* volumes of nitrogen and *three* volumes of oxygen form hyponitrous acid, which exists only in combination with a base. *Two* volumes of nitrogen and *four* volumes of oxygen form the nitrous acid already mentioned. *Two* volumes of nitrogen and *five* volumes of oxygen compose nitric acid or aquafortis, one of the most corrosive and deadly poisons. Thus of *all* the combinations of these two gases, atmospheric air is the *only* one fit for sustaining life."*

The establishment of these points, and especially that of the principle "of the diffusion of gases," by which they are caused to expand throughout the whole extent of the aerial ocean, ought to be received as the most convincing proof of the truth of the Mosaic record.†

* Introduction to Meteorology, pp. 6, 24, 13.

† It is also worthy of remark, how frequently throughout the sacred volume the finger seems to have been pointed to those discoveries long, long ago; and repeated, at intervals, throughout the whole course of the divine revelation, with a clearness only equalled by man's wayward reluctance to appreciate them. In proof of this, the following are a few from amongst the numerous passages which might be quoted, to show, that the expansive principle, now termed the "Diffusion of Gases," is as clearly indicated, as if volumes, detailing the results of experimental philosophy had been written on the subject.

"Hearken unto this, O Job: stand still and consider the wondrous works of God. Dost thou know the balancing of the clouds, the wondrous works of him which is perfect in knowledge? Hast thou with him spread out the sky, which is strong and as a molten looking-glass?" (Job xxxvii. 14, 16, 18.)

"O Lord my God, thou art very great; thou art clothed with honour and majesty: Who coverest thyself with light as with a garment; who stretchest out the heavens like a curtain?" (Psalm civ. 1, 2.)

"Have ye not known? have ye not heard? hath it not been told you from the beginning? . . . . . . It is he that sitteth upon the circle of the earth; . . . . . . that stretcheth out the heavens as a curtain, and spreadeth them out as a tent to dwell in." (Isaiah xl. 21, 22.)

"Thus saith the Lord, I *am* the Lord that maketh all things; that stretcheth forth the heavens alone; that spreadeth abroad the earth by myself." (Isaiah xliv. 24.)

"I have made the earth and created man upon it; I, *even* my hands, have stretched out the heavens, and all their host have I commanded." (Isaiah xlv. 12.)

"I, *even* I, *am* he that comforteth you; who art thou, that forgettest the Lord thy maker, that hath stretched forth the heavens, and laid the foundations of the earth?" (Isaiah li. 12, 13.)

"But the Lord is the true God, he is the living God, and an everlasting King. He hath made the earth by his power, he hath established the world by his wisdom. When he uttereth his voice, there is a multitude of waters in the heavens, and he causeth the vapours to ascend from the ends of the earth; he maketh lightnings with rain, and bringeth forth the wind out of its treasures." (Jeremiah x. 10, 12, 13, and li. 15, 16.)

These sublime passages, and innumerable others to the same effect, must convince

Whoever has paid any attention to what has been written on meteorology, must be aware, that the atmosphere comprehends two distinct bodies of colourless, inodorous, elastic fluids; the one of Air, the other of Vapour; the former composing, by far, its greatest volume and most important part, whose movements and changes give a tone to the whole: while the watery vapour, though comparatively insignificant in volume, or weight, is yet absolutely essential to the well-being and existence of the animal and vegetable kingdoms of nature. The truth of these assertions will appear more evident after perusing the following quotations:—

"We have seen," says Professor Whewell, "how many and how important are the offices discharged by the aqueous part of the atmosphere. The aqueous part is, however, a very small part only; it may vary, perhaps, from 1-100th to nearly as much as 1-20th in weight of the whole aerial ocean. We have to offer some considerations with regard to the remainder of the mass.

"In the first place we may observe, that the aerial atmosphere is necessary as a vehicle for the aqueous vapour. Salutary as is the operation of this last element to the whole organized creation, it is a substance which would not have answered its purpose if it had been administered pure. It requires to be dilated and associated with dry air to make it serviceable. . . . . .

"Besides our atmosphere of aqueous vapour, we have another and far larger atmosphere of common air; a *permanently* elastic fluid: that is, one which is not condensed into a liquid form by pressure or cold, such as it is exposed to in the order of natural events. The pressure of the common air is about 29½ inches of mercury; that of the watery vapour perhaps half-an-inch. . . . . .

"Now this mass of dry air is by far the most dominant part of the atmosphere; and hence carries with it in its motions the thinner and smaller eddies of aqueous vapour. The latter fluid may be considered as permeating, and moving in the interstices of the former, as a spring of water flows through a sand rock."*

"Though the air we breathe," says another writer, "was formerly considered a simple substance, it is now known to be a compound. Its constituents are nitrogen, oxygen, and carbonic acid gases, and aqueous vapour, existing in a state, not of chemical combination, but of uniform intermixture with one another. . . . . . The relative proportion of the aqueous vapour contained in the atmosphere is extremely variable, and is regulated in a great measure by the temperature of the air. . . . . . It has been estimated, that in Great Britain, during summer, the weight of water present in the atmosphere frequently amounts to 1-60th of the whole; whereas, in winter, it often does not exceed 1-300th of the whole. In warm latitudes, the weight of aqueous vapour contained in the atmosphere is frequently double what it is, during summer, in Great Britain, while in the polar

every impartial person that our ignorance cannot be chargeable to the Almighty; for no announcement in Scripture, having relation to material objects, is more consistent than this; for, wherever there is occasion to mention the atmosphere, the language uniformly made use of *indicates the expansion, or diffusion of the elements which compose it.*

* Bridgewater Treatise, pp. 96—99.

regions the proportion is extremely small. Dr. Dalton supposes, that the medium quantity of vapour held in solution by the atmosphere may amount to 1-70th of its bulk."*

"Water," says Dr. Thomson, "*vaporises* when it passes into *steam* at 212° Fahrenheit, under ordinary pressure; below that temperature it *evaporates*, passing into the ambient air in insensible moisture, where it is retained till a diminution of temperature renders it apparent; for Dalton found that the amount and tension of vapour in the atmosphere is independent of the presence of the air, and wholly regulated by caloric. Hence arise clouds, mists, and other aqueous meteors, when the thermometer falls in a humid atmosphere. In the state of vapour, the moisture exists normally in the form of hollow vesicles, frequently mingled, however, with globules filled with water. . . . . . The diffusion of aqueous vapour in the atmosphere is what is meant by its humidity. . . . . . The question whether aqueous vapour is chemically combined or merely blended with the atmosphere has not been determined. Berzelius, Berthollet, Saussure, and Thomson support the former theory, Dalton, Henry, and the author, the latter."†

What has thus far been said will be sufficient to explain the harmony which exists between the record of creation and the experience of natural philosophy, as regards the formation of the elements of the aerial part of the firmament, and their permanently expansive character, without reference having been made to the completion of the work; for *the Firmament or Atmosphere was not perfected, nor indeed could it have been, until the separation of the land from the water, on the third day of the* Mosaic Week.

Whilst the signification of the words "let there be a firmament in the midst of the waters; and let it divide the waters from the waters," appears to have reference not only *to the relative positions in space* of the waters which were thus separated from each other, by the agency of the firmament, but likewise apply (as the means of effecting that separation), to *the relative degrees of expansive principle with which any portion of the water is for the time being combined.*

This view of the subject will be found to harmonize with those which have been adopted, as the result of experiments, by philosophers, who have been induced to ascribe similar inherent properties to what is termed the "*dew point,*" or "*constituent temperature for the maintenance of water in a state of vapour.*" For, supposing the *Firmament* to be, as it assuredly is, *that constituent or Dew* point, and to be subject, itself, to variations according to altitude, temperature, and other concomitant circumstances (all indispensable for its perfection, as will presently be shown), then it can clearly be understood how it is that the waters "*under the firmament*" refer to those which, at any particular place, are in a negative or inferior degree of combination with the expansive principle, or lower than "*their constituent temperature*" in relation to the atmosphere, at the same time and place; and, on that account, by condensing, *incline*

* Principles of Meteorology, by Mr. Hutchinson, pp. 4—6.
† Dr. Thomson's Introduction to Meteorology, pp. 97, 100, 107.

to descend; while those again which are "*above* the firmament," have reference to such as are in excess of combination with the subtile element conferring expansion on them, and thereby they have become above their constituent temperature, and *are inclined to ascend.* Thus a division, varying in extent and degree, according to relative circumstances, is effected between these two portions of water, by means of the atmosphere, which, by being differently affected by heat, permits and enables the watery vapour to percolate through it with perfect freedom, whilst it likewise serves as a carrier, from place to place, of the aqueous portion.

"The temperature denominated *dew point,*" observes Dr. Thomson, "is that which represents the point at which vapour is deposited upon an object colder than itself. . . . . . The difference between the dew-point and mean diurnal, mensual, or annual temperature is the *mean dryness* of the same respective periods. The *mean dew point* is always below that of the mean temperature."

And again—

"Dew is the spontaneous appearance upon objects freely exposed to the atmosphere, of moisture which was invisible. . . . . . Dr. Wells is our chief authority on dew, and his theory, given in one of the most beautiful inductive essays in our language, is founded upon calorific radiation. . . . . . That it is the effect, not the cause, of the lowering of the temperature of the bodies bedewed."*

As the combination of the minute particles of water with the repulsive principle, is that which causes them to become watery vapour, and to ascend until they find their level in the atmosphere, they thereby naturally and spontaneously obey the law which was primarily impressed upon them. For, leaving the great body of the water, which remains uncombined, they ascend and are divided from it *both in temperature and in space,* as long as they continue in a positive state, or "above the firmament;" while they descend to rejoin their parent source, as soon as, from causes whose explanation will presently be attempted, they fall *below their* constituent temperature at the particular point of the atmosphere where they happen to be. And thus, the one state directly inducing the other, as cause and effect, the harmony prevailing between them manifestly shows the correctness of these assumptions, and which I shall now endeavour to prove, by the announcements of philosophy, to be also in accordance with the scientific facts of the case.

The *ninety-third* Theorem states, "*That the watery vapour of the atmosphere is due to the influence of* HEAT; *which, infusing the repulsive principle into the waters of the seas, rivers, and lakes, causes them to ascend in an aeriform state.*

"*That the ocean undergoes a continual process of evaporation, and dismisses into the atmosphere a quantity of pure water, proportionate to*

* Introduction to Meteorology, pp. 105, 108.

its extent of surface, to the temperature of the air, and to its state of saturation.

"*That whenever the temperature of the air is reduced below the limit at which the suspended vapour is maintained in a state of saturation, condensation takes place, and rain or aqueous clouds are produced.*

"*And that by these alternate processes, the terraine surface of our globe is supplied with fresh moisture and with water necessary to sustain the organization, and to maintain the functions of the animal and vegetable kingdoms.*"

Without giving any of the details of a theorem, so complete as almost to be sufficient explanation of the matter it involves, I shall pass on to the recapitulation of the remaining theorems relating to this particular subject; and, in conclusion, bring forward evidences common to them all.

The *ninety-fifth* Theorem states, in part—"*That the* VAPORIZATION *of a* FLUID *is accelerated by the increase of its temperature, and more so when heat is applied to a surface free from external pressure; in a vacuum vaporization is almost instantaneous. The agitation of the surface likewise increases the effect. That, in general, the rate of evaporation from the surface of the water, in all states of the atmosphere, will be proportioned to the tension of vapour which would saturate the atmosphere, diminished by the tension of the vapour actually in the atmosphere.*"

And, in continuation of the same subject, it is given in the *ninety-fourth* Theorem—"*That the following seem to be the most obvious principles, whose combinations and mutual action on each other govern and modify the meteorological state of the atmosphere, namely:—The existence of a constituent temperature for the maintenance of water in a state of vapour. The opposite tendencies of air from the colder to the warmer parts; and of vapour from the warmer to the colder parts of the atmosphere and terraqueous surface. The different rates at which the temperature and tension of air and of vapour decrease as they ascend from the surface of the earth or sea. The different capacities for heat of those two component parts of the earth's surface. And, lastly, the unequal distribution of the electric fluid in the nephalic masses of the atmosphere, and its tendency to a state of equilibrium.*"

The evidences common to these several propositions will tend, while they illustrate what has been said, to prepare the mind for what is to form the subject of the next section, when the use, made by the Creator, of the newly-formed atmosphere, in separating the water from "the dry land," by evaporation, will be considered, and its explanation attempted. Some sentences of these extracts have been quoted already, when illustrating other positions, but this is almost unavoidable; a passage written without reference to a particular subject, may contain a confirmation of two or three different parts of the same argument:—

"Besides our atmosphere of aqueous vapour," says Professor Whewell,

"we have another and far larger atmosphere of common air, a *permanently elastic fluid*, that is, one which is not condensed into a liquid form by pressure or cold, such as it is exposed to in the order of natural events. The pressure of the dry air is about $29\frac{1}{2}$ inches of mercury; that of the watery vapour, perhaps half-an-inch. Now, if we had the earth quite dry, and covered with an atmosphere of dry air, we can trace in a great measure what would be the results. The air at the equator would be modified by the heat, and would be perpetually displaced below by the denser portions which belonged to cooler latitudes. We should have a current of air from the equator to the poles in the higher regions of the atmosphere, and at the surface a returning current, setting towards the equator, to fill up the void so created. . . . . . .

"Now, a mass of dry air, of such a character as this, is by far the dominant power of our atmosphere: and hence carries with it in its motions the thinner and smaller eddies of aqueous vapour.

"The lower current of air is directed towards the equator, and hence it resists the motion of the steam, the tendency of which is in the opposite direction, and prevents or much retards that continual flow of hot vapour into colder regions; by which a constant precipitation would take place in the latter situations.

" . . . . . Thus in the lower part of the atmosphere, there are tendencies to a current of air in one direction, and a current of vapour in the opposite; and those tendencies exist in the average weather of places situated at a moderate distance from the equator. The air tends from the colder to the warmer parts, the vapour from the warmer to the colder.

"The various distribution of land and sea, and many other causes, make these currents far from simple. But in general the air current predominates, and keeps the skies clear and the moisture dissolved. Occasional and irregular occurrences disturb this predominance; the moisture is then precipitated, the skies are clouded, and the clouds may descend in copious rains.

"To produce this variety, we have two antagonistic forces, by the struggle of which such changes occur. Steam and air, two transparent and elastic fluids, expansible by heat, are, in many respects and properties, very like each other Yet, the same heat similarly applied to the globe, produces at the surface currents of those fluids tending in opposite directions. And these currents mix and balance, conspire and interfere, so that our trees and fields have alternately water and sunshire, our fruits and grain are successively developed and matured. . . . . .

"But we have not yet done with the machinery of the weather. In ascending from the earth's surface through the atmosphere, we find a remarkable difference in the heat and in the pressure of the air. It becomes much colder and much lighter; men's feelings tell them this; and the thermometer and barometer confirm these indications.

"In both the simple atmospheres of which we have spoken, the one of air, and the one of steam, the property we have mentioned must exist. In each of them, both the temperature and the tension would diminish in ascending. But they would diminish at very different rates. The temperature, for instance, would decrease much more rapidly for the same height in dry air than in steam. If we begin with a temperature of 80° at the surface, on ascending 5,000 feet the steam is still $76\frac{1}{2}$°, the air is only $64\frac{1}{2}$°;

at 10,000 feet the steam is 73°, the air $48\frac{1}{2}$°; at 15,000 feet the steàm is at 70°, the air has fallen below the freezing point to $31\frac{1}{2}$ degrees. Hence these two atmospheres cannot exist together without modifying one another; one must heat or cool the other, so that the coincident parts may be of the same temperature. This accordingly does take place, and this effect influences, very greatly, the constitution of the atmosphere. For the most part, the steam is compelled to accommodate itself to the temperature of the air, the latter being of much the greater bulk. But if the upper part of the aqueous vapour be cooled down to the temperature of the air, they will not, by any means, exert on the lower parts of the same vapour so great a pressure as the gaseous form of these could bear. Hence, there will be a deficiency of moisture in the lower part of the atmosphere, and if water exist there, it will rise by evaporation, the surface feeling an insufficient tension; and there will thus be a fresh supply of vapour upwards. As, however, the upper regions already contain as much as their temperature will support in the state of gas, a precipitation will now take place, and the fluid thus formed will descend till it arrives in a lower region, where the tension and temperature are again adapted to its evaporation.

"Thus, we can have no equilibrium in such an atmosphere, but a perpetual circulation of vapour between its upper and lower parts. The currents of air which move about in different directions at different altitudes, will be differently charged with moisture, and as they touch and mingle, lines of cloud are formed, which grow and join, and are spread out in floors, or rolled together in piles. These, again, by an additional accession of humidity, are formed into drops, and descend in showers into the lower regions, and if not evaporated in their fall, reach the surface of the earth. Here, then, we have another remarkable exhibition of two laws, in two nearly similar gaseous fluids, producing effects alike in kind, but different in degree, and by the *play* of their difference giving rise to a new set of results, peculiar in their nature and beneficial in their tendency. . . . . .

"From what has been said we may see, in a general way, both the causes and the effects of *winds*. They arise from any disturbance by temperature, motion, pressure, &c., of the equilibrium of the atmosphere, and are the efforts of nature to restore the balance. Their office in the economy of nature is to carry heat and moisture from one tract to another, and they are the great agents in the distribution of temperature and the changes of the weather. Other purposes might easily be ascribed to them in the business of the vegetable and animal kingdoms, and in the arts of human life, of which we shall not here treat. That character in which we now consider them, that of the machinery of atmospheric changes, and thus, immediately or remotely, the instruments of atmospheric influences, cannot well be refused them by any person"*

"Meteorology," observes Mr. Hutchinson, "is that department of physical science which treats of atmospheric phenomena. . . . . . Several of these are so mutually dependent upon each other, that with a view to explain their causes it is difficult to decide upon what arrangement ought to be adopted. For instance, variations of temperature on different parts of the earth's surface disturb the atmospheric equilibrium, and give rise to aerial currents; while, on the other hand, aerial currents, according as their direction is from a cold to a warm climate, produce important alterations in

* Bridgewater Treatise, pp. 98—106.

the temperature of the incumbent atmosphere. Again, variations in the atmospheric temperature are principally instrumental in the formation and dissolution of clouds; while, on the other hand, the existence of clouds reduces the temperature of the subjacent atmosphere during the day and summer, and augments it during night and winter.

"I am disposed to think," says he, at another part, "that the increased capacity of air for heat, according as the superior aerial compression diminishes, is either the true cause, or rather a constant and necessary concomitant of the true cause of the mean rate of decrease of temperature, upon ascending perpendicularly from the sea.

"The parent source," he continues, "from whence the atmosphere, when undersaturated, derives a supply of aqueous vapour, is the ocean. The process by which it is supplied is called evaporation, ... and, as a considerable proportion of the moisture which is precipitated upon the land is returned to the ocean by means of rivers, it is obvious that the land would soon become dried up, were it not supplied with humidity from the ocean, through the agency of evaporation and atmospheric currents." . . . .

"Clouds," says Dr. Prout, "are the great means by which water is transported from seas and oceans to be deposited far inland, where water otherwise would never reach. They, also, greatly mitigate the extremes of temperature. By day they shield vegetation from the scorching influence of the solar heat; by night, the earth, wrapt in its mantle of clouds, is enabled to retain that heat which would otherwise radiate into space; and is thus protected from the opposite influence of the nocturnal cold. . . . . And whether we contemplate them with respect to their form, their colour, their numerous modifications, or, more than all, their incessant state of change; clouds prove a source of never-failing interest, and may be classed among the most beautiful objects in nature." . . . . .

And lastly, from this writer—

"When treating of the formation of the *Fall-cloud*, we explained the causes and principles which, according to the experiments of Dr. Wells, determine the formation of dew. . . . . . This consists of moisture precipitated from the aerial strata nearest the ground, in consequence of coldness (induced by radiation of caloric from the earth's surface during calm, clear nights) being communicated to those strata in sufficient intensity to produce over-saturation. Hence, agreeably to the beneficent designs of Providence, by which scarcity produces provident economy, and by which all phenomena are adapted upon the wisest principles to serve useful purposes, frugality in its distribution is observed to be proportionate to the smallness of its quantity; and, according to Dr. Wells, 'appears chiefly where most wanted, on herbage and low plants, avoiding in great measure rocks, bare earth, and considerable masses of water. Its production, too, by another wise arrangement, tends to prevent the injury that might arise from its own cause, since the precipitation of water upon the tender parts of plants must lessen the cold in them which occasions it.' "*

"As the capacity of air for moisture varies with its temperature," observes Mr. Graham, "the attention of philosophers has been directed to ascertain the relative ratio of variation. . . . . . Judging from the experiments which have been made, it appears, that while the temperature of

* Principles of Meteorology, by G. Hutchinson, Introd. pp. 117, 177, 222.

air increases in arithmetical progression, its capacity for holding moisture in invisible solution increases in geometrical progression, or very nearly so. And in every increment of temperature amounting to about 23°.4 of Fahrenheit's scale, the capacity of air for moisture is doubled. Thus, if the capacity of air for moisture be denoted 1 at the temperature of zero, it will be 2, or double the zero capacity, at the temperature of 23.4; 4, or the quadruple, at 46.8; eight times the zero capacity at the temperature of 70°.2; and sixteen times the zero capacity at the temperature of 93°.6, &c.

"It has been ascertained, that the temperature of the atmosphere, in all latitudes, diminishes on ascending perpendicularly from the level of the sea; but the rate of diminution, as determined by different observers, and even by the same observer, at different times and places, varies greatly. . . . . .

"When the humidity or the dryness of the atmosphere is mentioned, reference is made, not to the absolute amount of moisture in the air, but to the amount in relation to its capacity. The more undersaturated the atmosphere is, the drier it is said to be, and the stronger is its influence in promoting evaporation from moist surfaces. On the contrary, the nearer it approaches to saturation, the more humid it is, and the less its influence in promoting evaporation. . . . . . The precipitation of moisture into the visible form of mist or clouds, may arise either from the reduction in the temperature of the atmosphere, or from a reduction in reference to its capacity.

"Dr. Thomson says, 'though there is no doubt that clouds consist of a congeries of vesicles, we have no conception of the way in which these vesicles are formed. . . . . . The formation of clouds, indeed, seems to be connected with electricity, though in what way the vesicular form is induced by electricity, we have no conception. The vesicles seem to be all charged with the same kind of electricity. This causes them to repel each other, and of course prevents them from uniting into drops of rain.' . . . . .

"And again he says, 'air and all gases are non-conductors; but vapour and clouds, which are composed of it, are conductors. Clouds consist of small hollow bladders of vapour, charged each with the same kind of electricity. It is this electric charge which prevents the vesicles from uniting together, and falling down in the form of rain. Even the vesicular form which the vapour assumes, is probably owing to the particles being charged with electricity. The mutual repulsion of the electric particles may be considered sufficient (since they are prevented from leaving the vesicle by the action of the surrounding air, and of the surrounding vesicles), to give the vapour the vesicular form."*

"The experiments of the illustrious Dalton and Guy Lusac," says the author of the Philosophy of Storms, "have shown, that when the dew-point is 80° Fahrenheit, and the barometer 30 inches, the quantity of vapour in atmospheric air is 1-48th of the whole weight, and 1-30th of the whole bulk; when the dew-point is 71° the quantity is one-fourth less; and when that constitutional point is 59° the quantity of vapour is one-half as much as when it is at 80°, while at 39° the quantity would be reduced to one quarter."†

These evidences demonstrate to a certainty, that the view adopted

* Principles of Meteorology, by G. Hutchinson, pp. 9, 17, 153. Dr. Thomson on Heat and Electricity, pp. 274, 440. Also Dr. Wells on Dew.

† Philosophy of Storms, p. 1.

of the separation of waters *under* the firmament, from waters *above* the firmament imply, that the latter were abstracted from the dominion of gravity by combination with the expansive principle, and thereby caused to ascend until they found their level *upwards;* while those which were *not* thus combined, but remained in their former state, were so far under the dominion of the gravitating power, that they sought—as waters do in their natural state—their level *downwards.*

This instance may be offered as a most satisfactory confirmation of the position formerly assumed, namely, that the division of the light from the darkness, *consisted in the* DIVERGENCY *of the tendency of their influences in space;* the former propending from the centre towards the circumference; the latter from the circumference towards the centre. For, as these two are the only instances where the term *divide* occurs, they seem mutually to shed an explanatory light on each other. And it is worthy of remark, that the same principle, *the* LIGHT or EXPANSION, was employed to effect this separation, evidently without any new character having been impressed upon it for that purpose; but taken up and made use of as an agent already capable of conferring expansion or repulsion. "Let there be a firmament (or expansion) in the midst of the waters, and let it (*i. e.* the expansion) divide the waters from the waters." And when we further reflect, that the expansive principle employed on this occasion *must have been the newly-formed light;* for the opposite principle—attraction—had existed for ages upon the water—"Darkness was upon the face of the deep"—*without having produced an atmosphere or firmament,* it cannot fail to afford an additional testimony to every candid mind, *that the division of the light from the darkness,* on the first day of the Mosaic week, *was the means of conferring an expansive principle upon the light;* and, that the new principle, thus formed, was made use of as the agent in effecting the division of "the waters which were *under* the firmament from the waters which were *above* the firmament."

This conclusion, it is apprehended, is perfectly correct; yet lest any doubt should still harbour in the mind from the suspicion, that when the firmament or atmosphere was formed, some additional *material or ponderable substance* was introduced into the universe; that is, some *new matter added* to the earth, occasion is taken to show by the simple application of one of the most accredited laws of mechanics, motion and momentum, that no such addition was made. It is stated in the two concluding paragraphs forming the *fifth* rule of the *seventy-third* Theorem, "that weights, *which are as one to two,* revolving at equal distances with the same velocity, will have their centrifugal forces as one to two; the centrifugal force increasing as the mass of the moving body increases," and consequent on this invariable law of mechanics, had any addition been made to the *matter,* or, in other words, to the *weight* of the world by the forma-

tion of the atmosphere, the angular momentum of the earth's rotation would have increased in a corresponding ratio; and so would also its centrifugal impetus around the sun; and, thereby, both its diurnal rotation and its orbital motion in space, would have been acted upon and disturbed. Nor is this all. By the further application of the same laws—those of mechanics—the special nature can be determined of that which was added to the material radicle or base of the atmosphere, to give it expansion, and we can also ascertain the precise period, almost to an hour, when this was done; for we find by the *second* rule of the *same* Theorem, "that weights revolving with the same angular velocity, *at distances from the centre in the proportion of one to two*, have their centrifugal force in the same proportion." Therefore, *whatever of* MATTER *is embodied in the atmosphere* was raised at once to the height *above* the surface, or distance *from* the centre, by the centrifugal impetus impressed on the earth by its first rotation round its axis, and by the impartation of the expansive principle, when such *matter* was driven off from the centre to that distance which the figure of rotation demanded; and that whatever was added thereto, to constitute the firmament or atmosphere, did not possess *the slightest appreciable gravity*. The only elements in nature known to be so circumstanced are light, heat, and electricity; consequently, some one of these modifications of the expansive principle must have been that which was applied to form the buoyant constituent of the atmosphere; and which thoroughly agrees not only with the announcement "Let there be a firmament in the midst of the waters, and Let it divide the waters from the waters," but is also in strict accordance with the latest conclusions which have been come to, on the subject, by philosophical writers.

"The Meteorology of the present epoch," says Dr. Thomson, "is very different from that of Aristotle and his pupil Theophrastus, or even that of the early years of the present century. The unwearied labours of a goodly host distributed over the globe, have been already amply rewarded, and we look forward with no small expectation to 'coming events,' which, in the discoveries of Faraday, may be said to have 'cast their shadows before.' The various phenomena described are not the offspring of separate causations, but functions of common principles. The intimate connection of agency, of heat and electricity, is apparent in the *tout ensemble* of the science. The former is the *primum mobile* of meteorology, and oxygen, nitrogen, and hydrogen, the elements on and with which it operates. . . . . .

And at another place he observes—

"The experiments of Dr. Faraday have established, 'a true direct relation and dependence between light and the magnetic and electric forces; and thus a great addition is made to the facts and considerations which tend to prove, that all natural forces are tied together and have *one common origin*.'"*

Indeed, unless the atmosphere had been formed on the *second* day

* Introduction to Meteorology, 1849, pp. 440, 278.

of the Mosaic week, there would have been an *unaccountable hiatus* in that period, as regards the LIGHT, that potent element so recently introduced into the universe by the Creator. It has already been shown, that it was this which was made use of on the *first* day to cause the earth (and we conclude the other spheres also) to rotate around their respective axes; and, likewise, that the primary light was employed on the *third* day to separate the water from the land, and to form the phanogamous classes of the vegetable kingdom. Consequently, unless there was a commensurate amount and importance of work performed, under divine direction and power, by the primary unconcentrated light, on the *second* day, there would be the hiatus alluded to: and unless that work was the firmament or atmosphere, it is impossible to account for it during a period, when it is positively known to exist, by what it was made to do both before and after, THAT IT DID EXIST.

The fact has already been adverted to, that however influential and all-pervading the centrifugal force, engendered by the first rotation of the earth around its axis, must have been; and however certainly it would have the effect of repelling part of the primitive circumfluent water to a considerable distance beyond its original level; and, to a certain extent, filling with its comminuted particles part of the space now occupied by the atmosphere; yet, *the force in question, so long as it was unaided, was quite incapable of having sent any particles of a material description to such a distance as forty or fifty miles from the earth's surface*—a height to which it is ascertained the firmament or atmosphere extends. It is when labouring under this difficulty that it is most easy to recognise in the principle of diffusion, or the alliance of the material bases of the atmospheric elements with the expansive principle of light, whereby they are buoyed up to the height in question, an admirable and simple explanation; the true *rationale* of what, otherwise, would have been wholly inexplicable, upon the supposition of the centrifugal force alone having effected the object in question; and to be grateful to science for the discovery which not only has relieved the mind from anxiety on this score, but made manifest in so clear and forcible a manner the wisdom and power of the Creator.

Before proceeding farther, let us pause to reflect a moment upon the signal corroboration of the Dynamical Theory, which is afforded by what has now been described. Unless it had been recorded, that there had been formed, at this precise juncture, an aggregate body so enormous as to cause a pressure of 15lbs. for every square inch of surface of the terraqueous globe! this theory would have been brought to an abrupt and unsatisfactory termination.

It cannot have been forgotten, that when explaining, in previous sections, what took place underneath the dark and atmosphereless water of the primitive ocean, when the stratiform masses of the earth's outer crust were being deposited, it was shown that this essen-

tial labour was chiefly conducted by innumerable tribes of zoophytic, testaceous, and others of the invertebrate class of animals, and by the secretion of widely-extended patches of flowerless submerged plants. And, that after the animal existences had encrusted themselves with coatings of carbonate of lime, and had fulfilled their other destinies, they died; and from the decomposing materials of their fleshy remains there arose never-ceasing streams of ammoniacal and other gaseous exhalations, in small, almost imperceptible increments, it is true, but in consequence of the myriads on myriads of these invertebrate creatures, and the ages during which these decomposing processes were going on, they must have amounted, in their aggregate, to enormous accumulations; and that by means of the plants, in a somewhat analogous manner, the ancient water became surcharged with free oxygen.

It was also made manifest, that in conducting the double process of forming and causing the deposition of the mineral stratified crust of the world, and in purifying the universal menstruum, to fit the former for becoming the terraine portion of the earth, and the latter for becoming the present seas, it pleased the Creator, by means of the various agencies employed for that purpose, *to separate the original contents of the primeval water into two distinct divisions:* one of which, by organic agency and electrical influences, was caused to be concreted into solid, indissoluble masses, which thereby descended to and remained at the bottom; every particle of matter in the primitive water fitted for such purposes having been drawn downwards, and become consolidated into strata, and there detained until the proper time came when, by means of the centrifugal impetus of the first rotation, these solidified deposits were made to start up and stand erect, to form the rocky barriers of the residual water. *Of this solid and enduring section of the primary matter, a sufficient and a satisfactory account has been given.* They now constitute the upheaved barriers of the ocean; the stratiform masses of the world!

The other section of matter, however, which was thus being divided during the process of purification, took an opposite direction and went *upwards*. And one of the principal ingredients which thus arose from the decomposition of the submerged animal matter was ammonia, which, owing to its specific levity, or what is the same, its relative size of volume, and the facility with which it combines with water, percolated *upwards* until it reached the higher strata of the ancient ocean.

And in continuation, this state of matters during the incipient period of the earth's history, was shown to be no figment of the imagination, but that it did necessarily exist; indeed, could not, according to the laws governing matter, and under the allowed circumstances, have been otherwise. For so surely as there were successive races of animal forms at the bottom of the primitive ocean, and their fossil exuviæ abundantly testify that there were, so surely

must these living, mortal creatures have died; and so surely as they died, so certainly and unavoidably must their fleshy remains have decayed, decomposed, and resolved themselves into those gaseous exhalations which proceed from putrid animal matter, one of which, and the principal one, is the alkaline substance *ammonia*.

If the innumerable myriads of living creatures, whose fossilized and indurated coverings compose a vast proportion of the calcareous strata, and the prevalence of this description of rock be taken into account; the ages which must have passed whilst these were being formed, and whilst the primeval waters were being brought into a state of preparation to be the seas of the present day be considered; we shall be able to arrive at an approximative conception *of the enormous accumulation of the alkaline ingredient ammonia, and of the free oxygen, which must have been stored up towards the conclusion of the non-rotatory period.* Indeed, nothing short of an aerial ocean, such as the atmosphere, which envelopes the whole earth, to the height of nearly 50 miles, and whose aggregate weight is that of 5,292,623,739,744,000 tons, or nearly five thousand three hundred billions of tons; the *nitrogen* or *azote* alone of which was derived from the ammonia in question, and whose enormous weight is 4,093,853,510,757,856 tons; or, in round numbers nearly four thousand one hundred billions of tons, could possibly have required the protracted accumulations which have so often been alluded to, and insisted upon. And fortunately it is requisite to account, at this juncture, by the formation of the atmosphere, for quantities which represent these vast accumulations, as this Theory would, otherwise, have been incomplete.

The following remarkable corroboration, so far as it goes, of the approximative correctness of these estimates, has been given in Dr. Thomson's recent meteorological work, published some years after these computations were made.

"The weight of the entire atmosphere is equal to a sea of mercury covering the superfices of our globe to the depth of 30 inches. The pressure is equal to nearly 14.6lbs. avoirdupois upon each square inch, or, 58,611,548,160lbs. upon every square mile. The pressure of the atmosphere may be thus estimated at about 8ozs. avoirdupois for every inch of mercurial elevation of the barometer. The absolute weight of the atmosphere, assuming the superfices of our globe to be 790,116,426,647,756,800 sqr. inchs., amounts to the enormous sum of 11,456,688,186,392,473,600lbs., equivalent, according to Dr. Cotes, to the weight of a globe of lead sixty miles in diameter. Pascal computes the whole mass of air at 8,983,889,440,000,000,000 Fr. lbs. Thus the weight of the atmosphere is equal to above eleven trillions of lbs. *English notation,* a sum which words may express and figures tabulate, but the mind cannot appreciate. Reduce this amazing weight to tons, and the mind is still unable to conceive the full value of the product—5,114,592,940,353,782. Compared with the weight of the globe this mighty sum dwindles to insignificance. Unite the two, and none but an Almighty mind can form an adequate conception,

none but an Almighty arm could hurl it through space, and give to its motions a regularity obedient to fixed laws. The same Almighty power alone could institute these laws.*

The proper consideration of all that has been brought forward, respecting this evident two-partite division of the associated elements of the ancient ocean, taken in combination with the explicit announcements made in the Mosaic record regarding them, unfold to the mind a remarkable uniformity of proceeding and oneness of design, both *before* and *after* the rotatory period: this event important as it may appear, and as, in reality, it was to the whole material universe, exercised not the slightest influence over *the great leading principles which continued uninterruptedly to direct the entire plan of creation.* By what has just been demonstrated it is evident, that the operation of separating masses of matter into two, by causing one division to unite itself closer with the *gravitating principle* and to go downward, and by associating another portion of the same mass with the *expansive principle,* and induce it thereby to adopt an opposite or an upward tendency, had been going on for ages before the formation of the physical light. When this was willed into existence, the first impulse given to it was *to divide it from the darkness.* By the application of the expansive influence, the spheres were caused to rotate, the waters *under* the firmament were *divided* from those *above* the firmament. And, in continuation, the residual waters were *separated* from the dry land, and the two unitedly stood

* Introduction to Meteorology, p. 25.

It may be interesting to know by what process I arrive at this array of figures, representing the weights of the whole atmosphere, and of the azote in it, respectively, in billions of tons, quantities scarcely appreciable by the mind, yet deduced from undeniable data.

We have, first of all, the diametres of the earth, 7,899 and 7,925 miles, and assuming the surface to be level, these give for the entire superfice, 196,878,115 square *miles*, and consequently 790,365,145,135,104,000, say seven hundred and ninety thousand three hundred and sixty-five billions one hundred and forty-five thousand one hundred and thirty-five millions one hundred and four thousand *square inches;* and as the aggregate weight of the atmospheric elements is equal to 15lbs. for every one of these square inches, we have, of course, one ton of 2,240lbs. equal to square inches 149,333, which becoming the divisor of the above surface in square inches, gives 5,292,623,739,744,000 tons as the weight of the entire atmosphere. The *azote* being estimated at 77.55-100ths of thè weight of that body, we must take 790,365,145,135,104,000$\times$0.7755= 611,347,439,762,002,944$\div$149,333=4,093,853,510,757,856 tons for the azote alone.

Will this world-wide retort, this atmosphere—in which are stored up, in combination with the expansive principle, the ammoniacal exhalations of so many by-gone generations of invertebrate creatures—ever reveal to man the lapse of ages which passed while as yet the earth was without rotation? Will it ever, by its known weight of azote, be made an index of undenoted time? If there be found to be any connexion between, or any proportion common to, the duration of a mollusc and the amount of ammonia rendered up by its decaying remains, whereby the longevity of an ancient mollusc would be to the duration of a modern one as their respective exhalations, and the data were ascertained by the latter, then some approximation might, perhaps, if considered necessary, be come to as to the whole period required to produce the azote of the atmosphere, and consequently the period of non-rotation, due allowances being made for all other attendant circumstances, and proportional periods allowed for the prior formations containing no organic remains.

forth, in pleasing variety, as a fitting pedestal for the plants and animals of the more recent world. Whilst the same principle seems to have been carried out even in the formation of these; animal and vegetable organic forms, endowed with life and vegetable vitality, having been *separated* from the more inert materials which constituted the terraqueous globe. In short, the great leading feature of the creation seems to have been SEPARATION. A separation between that which was, and which still continues to be, to a certain extent, under the influence of ATTRACTION, and that which, by the immediate agency of the Creator, has been immutably placed also, in degree, under the dominion of LIGHT OR EXPANSION.

So far as has been revealed the extent of this principle of *separation* can be traced; how far it really extends, is not for us, as finite beings, to enquire. The veil which has been thrown over this subject ought neither to be touched nor drawn aside: our becoming position is obeisance before it, and reverence to His will who alone can know what might have been the consequences had His hand not been stretched forth "at the beginning," to overrule the influence of "the darkness which reigned upon the face of the universe!" This course, which fortunately puts all conjecture at an end, *has been adopted;* and it is our duty, now, in place of seeking "to interfere in things which are too high for us," to receive with reverence the revelation which has been made respecting it; and, whenever in our power, to endeavour to apply the knowledge, thus acquired, to the glory of the Creator.

SECTION VI.

METEOROLOGICAL PHENOMENA RESULTING FROM THE LIGHT, AND FROM THE EARTH'S PROTOROTATION.

CHAPTER XXXI.

The subject of the previous Chapter continued. Atmospheric phenomena. Scientific evidence of the manner in which the *Aerial* and the *Aqueous* portions of the Atmosphere respectively act under the influence of a common cause. Scriptural and Philological confirmations of these announcements. Application of the information acquired from both of these branches, to the further elucidation of the Dynamical Theory.

FOLLOWING up the design, which was contemplated in the previous chapter, of preparing the mind for the investigations which will soon have to be undertaken in a subsequent part of this work, I shall now proceed to enquire into some of the other conditions of the atmosphere, namely, the manner in which the aerial and the vapourous portions conduct themselves under meteorological changes affecting them both. For this purpose let us refer to the *eighty-eighth* Theorem, which states, "*That when a space is filled with a mixture of gas and vapour, these two bodies act, under changes of volume, in exactly the same manner as they would if each separately occupied the whole space; the gas dilates and contracts, changing its pressure and temperature with its density. The vapour obeys the same law, so long as no part of it is condensed into a liquid; but as compression renders condensation more easy by the more rapid development of heat, when much compression is used, a portion of that caloric necessary to maintain the vapour in the aeriform state will escape. A corresponding quantity of the vapour will become liquid; and the remainder will be mingled with the gas, having the same tension which it would have if the gas were not present.*" And in connection with this, we shall again refer to a clause of the *ninety-third* Theorem, although it has been already recapitulated, "*That whenever,*" *by any meteorological cause,* "*the temperature of the air is reduced below the limit at which the suspended vapour is maintained in a state of saturation, condensation takes place, and rain or aqueous clouds are produced.*"*

*** See also 94th Theorem and evidences.**

The following are some of the evidences :—

"Clouds," says Professor Whewell, "are produced by aqueous vapour, when it returns to the state of water. This process is *condensation*, the reverse of evaporation. When vapour exists in the atmosphere, if in any manner the temperature becomes lower than the *constituent temperature* requisite for the maintenance of the watery state, some of the steam will be condensed and will become water. It is in this manner that the curl of steam from the vent of a steam boiler becomes visible, being cooled down as it rushes into the air. The steam condenses into a fine watery powder, which is carried about by aerial currents. Clouds are of the same nature with such curls, the condensation being generally produced when air, charged with aqueous vapour, is mixed with a colder current, or has its temperature diminished in any other manner. Clouds produce *rain*. In the formation of a cloud the precipitation of moisture probably forms a fine watery *powder*, which remains suspended in the air in consequence of the minuteness of its particles; but if from any cause the precipitation is collected in larger portions and becomes *drops*, these descend by their weight and produce a shower."

At another part of his Treatise, when noticing the laws of electricity, he adds—

"We cannot trace very exactly the precise circumstances in the occurrences of the atmospheric regions, which depend on the influences of the laws of electricity; but we are tolerably certain, from what has been already noticed, that if these laws did not exist, or were very different from what they now are, the action of the clouds and winds, and the course of vegetation, would also be other than it now is. It is, therefore, at any rate very probable that electricity has its appointed and important functions in the economy of the atmosphere, and this being so, we see a use in the thunder-storm and the stroke of the lightning. These violent events are, with regard to the elasticity of the atmosphere, what winds are with regard to heat and moisture. They restore the equilibrium where it has been disturbed, and carry the fluid from places where it is superfluous to others where it is deficient. In the natural world, these apparently destructive agents are, like all the other movements and appearances of the atmosphere, parts of a great scheme, of which every discoverable purpose is marked with beneficence as well as wisdom."*

"When the air," says the author of the 'Philosophy of Storms,' "near the surface of the earth becomes more heated, or more highly charged with aqueous vapour, which is only 5-8ths the specific gravity of atmospheric air, its equilibrium is unstable, and upmoving columns or streams will be formed. As these columns rise their upper parts will come under less pressure, and the air will therefore expand; as it expands, it will grow colder about one degree and a quarter for every hundred yards of its ascent, as is demonstrated on the nephelescope.

"The ascending columns will carry with them the aqueous vapour which they contain, and, if they rise high enough, the cold produced by expansion, in consequence of diminished pressure, will condense some of the vapour into cloud; for, it is known, that clouds are formed in the receiver of an air-pump when the air is suddenly withdrawn. The height to which the

* Bridgewater Treatise, pp. 85, 89, 111, 112.

air will have to ascend before it be cold enough to form clouds is a variable quantity, depending on the number of degrees which the dew-point is below the temperature of the air. . . . . . And the difference between the dew-point and the temperature of the air in degrees is called the complement of the dew-point.*

"Mists and clouds," says Mr. Hutchinson, "seem to consist of a multitude of hollow vesicles or bladders, the coatings of which are inconceivably thin, and similar in structure to those usually blown from soapsuds. These vesicles vary in size, according to the measurement of De Saussure, from 1-4222nd to 1-2620th of an English inch in diameter. . . . . . This is farther proved by the circumstance of their specific gravity being such, that they remain suspended in the air without any tendency to descend, and even on frequent occasions are seen to ascend; whereas, if they consisted of round drops, without any internal vacuity, their descent would be rapid.

"Clouds, in order to their suspension, must displace a weight of atmosphere equivalent to their own. The dissolution of clouds is effected in two ways, viz.—by falling in rain, or by evaporation and reconversion into invisible vapour.

"That the formation of clouds is a necessary antecedent to rain, is proven by the fact, that rain never falls unless the sky immediately vertical be obscured by clouds. But though clouds be essential to its production, they never produce it until they have acquired a considerable degree of density. But how does it come about that the aqueous vesicles lose their vesicular form, and descend to the earth in drops of rain? . . . . . Upon reflecting on the different degrees of rapidity with which rain falls at different times, and in different climates, I am disposed to think that the capacity of the atmosphere for suspending aqueous vesicles is limited, and varies with its temperature; and from the greater density of clouds in warm climates, as well as the greater amount of rain which falls from them in a given time, it seems probable that the capacity of the air for suspending vesicles, like its capacity for holding moisture in invisible solution, increases with its temperature. . . . . . Provided other things be equally favourable, the annual amount of rain that falls, and the heaviness of the showers, are greatest at the equator, and diminish as we ascend towards either pole; . . . . . . while the rainy direction of winds, in all latitudes beyond the tropics, is when it blows in the lower half of the atmosphere from a warm towards a comparatively cold climate."†

"When the air can no longer retain the moisture blended with its particles," observes Dr. Thomson, "it descends in drops upon the earth, purifying the atmosphere through which they fall, and fertilizing the ground with refreshing rain. This, or melted snow, is the purest of natural waters, though, in consequence of its solvent power, it generally contains some extraneous ingredients. . . . . . The amount of rain, or meteoric water, which falls upon the ground, is greatest in the tropics, and decreases as we approach the poles. The physical features of the locality influence considerably the quantity. . . . . . It was reserved for Sir John Leslie to illustrate what Hutton satisfied himself with merely enunciating respecting the production of rain. 'Suppose,' says Sir John Leslie, 'equal bulks of air in a state of saturation, and at the different temperatures of 15° and

* Introduction, pp. viii. lx.

† Principles of Meteorology, by G. Hutchinson, pp. 122, 152, 172, 196, 197, 321.

45° per cent., were intermixed, the compound arising from such union will evidently have the mean temperature of 30 degrees. But since, at these temperatures, the one portion held 200 parts of humidity, and the other 800, the aggregate must contain 1,000 parts, or either half of it 500; at the mean or resulting temperature, however, this portion could only suspend 400 parts of humidity, and consequently the difference, or 100 parts, amounting to the 200th of the whole weight of air, must be precipitated from the compound mass.' But this commixture simply, of strata of humid air at different temperatures, will, in most cases, produce a very small effect, though sufficient to account for the production of a shower. The aid of electricity, as Dr. Traill observes, must be called in to furnish a satisfactory explanation of all the phenomena. In endeavouring to explain the suspension of the clouds, the individual particles were found to be charged with, and surrounded by, electricity. It is merely necessary that this should be withdrawn to have a coalescing of the vesicles and their precipitation, or upon the approximation of clouds charged with electricity in its opposite states, the attraction of the humid spherules, their coalescence, and descent, either to the earth, or for the formation of a cloud in a lower strata of the atmosphere."*

From what has now been adduced, it is perfectly evident that the *aerial body* of the atmospheric ocean possesses a character entirely distinct from the *vapourous portion* of the atmosphere; and with relation to certain elements, such as heat, wholly different and opposed to it; while a third position has been as clearly and convincingly demonstrated, namely, that unitedly, these two fluid masses, the one contained, as it were, in the interstices of the other, possess a

* Introduction to Meteorology, pp. 132, 133, 147.

The following evidences from Scripture may be perused with advantage, in addition to those which have been drawn from philosophical sources:—

"Whence then cometh wisdom? and where *is* the place of understanding? God maketh the weight for the winds, (how conformable is this to modern philosophy, which teaches, *that winds propend to the rarefied parts,*) and he weigheth the waters by measure. When he made a decree for the rain, and a way for the lightning of the thunder. (Job xxviii. 20, 25, 26.)

"By the breath of God frost is given; and the breadth of the waters is straitened. Also by watering he wearieth the thick cloud; he scattereth his bright cloud. And it is turned round about by his counsels; that they may do whatsoever he commandeth them upon the face of the world in the earth." (Job xxxvii. 10—12.)

"Who hath divided a watercourse for the overflowing of waters; or a way for the lightning of thunder; To cause it to rain on the earth, *where* no man *is; on* the wilderness, wherein *there is* no man; To satisfy the desolate and waste *ground,* and to cause the bud of the tender herb to spring forth? Hath the rain a father? or who hath begotten the drops of dew? Out of whose womb came the ice? and the hoary frost of heaven, who hath gendered it? The waters are hid as *with* a stone, and the face of the deep is frozeu." (Job xxxviii. 25—30.)

"Behold, God *is* great. For he maketh small the drops of water; they pour down rain according to the vapour thereof, which the clouds do drop *and* distil upon man abundantly." (Job xxxvi. 26—28.)

"Whatsoever the Lord pleased, *that* did he in heaven, and in earth, in the seas, and in all deep places. He causeth the vapours to ascend from the ends of the earth: he maketh lightnings for the rain; he bringeth the wind out of his treasuries." (Psalm cxxxv. 6, 7.)

"When he uttereth his voice, *there is* a multitude of waters in the heavens, and he causeth the vapours to ascend from the ends of the earth; he maketh lightnings with (or for) rain, and bringeth forth the wind out of his treasures." (Jeremiah x. 13.)

a character, and produce effects, different from what they could have done, had they remained separate: and likewise, that without being chemically united, and thereby resulting in a *third* substance unlike to either, although in mechanical combination, and each retaining its own individual character, they nevertheless, conjointly, produce results which, separately, neither could have effected.

This peculiar adaptation of means to the end, the most beneficent and life-sustaining which could have been devised, appears to be clearly indicated by the phraseology of Scripture.* By reference to it there will be manifestly seen, that the aerial part of the atmosphere was formed distinctly from the aqueous portion; indeed, the one, after being formed, was the means of effecting the other. "Let there be a firmament in the midst of the waters, and let *it* divide the waters from the waters." The *firmament* itself being that, which was to effect the division between waters and waters, afterwards shown to have been the waters "which were *under* the firmament from those which were *above* the firmament." For it is perfectly conclusive, that before the firmament could have produced any effect, it must, itself have been made. No sooner, however, is it constituted, than it is employed to produce a consecutive series of effects, namely, to separate, in space, those waters which were combined with, what must for the present and for the sake of the argument, be called *something else*, and so made to be *above* the firmament's constituent temperature, from those which were *less* combined with the same entity, and so were *under* its constituent temperature. Nothing can be more evident, than that it could not have been the atmosphere itself with which those waters were combined, in order that they should become *above* the firmament. It is foreign to the law of cause and effect, that any lighter body, by combining with a heavier body, can confer upon the latter a buoyancy *greater than itself*. Again, we need scarcely hesitate a moment to come to the conclusion, that it was *not* attraction with which that portion of the water was combined, which became *above* the constituent condition of the firmament, for the primeval ocean had been, as it were, swathed therewith for ages without any such effects having been produced; nor, indeed, were they produced until the most subtile and buoyant of all elements, LIGHT, was introduced into the material universe; and then, immediately thereafter, the firmament is stretched forth. This will be perceived the more clearly when it is considered that it was the impartation of LIGHT to the more material elements which principally occupied the attention of the Omnipotent during the period selected for perfecting the creation. That, in fact, LIGHT was the chief agent employed in carrying on those works. The assurance that the phenomena, which are now being more immediately contemplated, required LIGHT, and LIGHT only, to render them complete and intelligible, will greatly convince

* Genesis i. 6—8.

us of being on the straight path to a right elucidation; and more especially so, should we adopt M. Peltieri's theory, in which he connects the phenomena of electricity with those of light and heat, upon the undulatory hypothesis of those fluids.

This consideration will appear the more to be relied upon when we reflect, that it is precisely when most at a loss to explain how any material substance whatever could have been repelled to a distance *of nearly fifty miles from the surface of the earth* by the only force which can be recognised as at all likely to have effected this, namely, the centrifugal impetus of rotation, that the discovery of the innate diffusion of the gaseous elements of the atmosphere, or their permanent connexion with the buoyant principle of light, comes opportunely forward to explain the enigma.

To remove, entirely, the scruples of any who may still be disposed to doubt whether these elements of the atmosphere may not owe their extreme elevation to the centrifugal impetus of the first diurnal rotation, reference need only to be made to those laws of mechanical momentum, whose aid has been already so frequently and so successfully sought, to be wholly convinced by them, that it would be the *heavier*, and not the *lighter* materials composing the non-rotating spherical earth's surface which would, on the eventful occasion of its protorotation, have been thrown farthest into space, or further from the centre; for, according to the *fifth rule* of the *seventy-third* Theorem, "*Weights which are as one to two, revolving at equal distances, with the same velocity, will have their centrifugal forces as one to two; the centrifugal force increasing as the mass of the moving body increases;*" an insuperable law of matter, which, wherever gravity exists, must put an end to any lingering conception, that it might have been the earth's first rotation which expanded the watery vapours and aerial ingredients of the atmosphere to their present elevated position above the surface of the earth and sea.

A closer investigation into the reasons assigned by meteorologists for the formation and suspension of clouds and visible vapour in the atmosphere, will prove, that they *assume*, as a fundamental position, although they do not expressly assert it to be so, that the aerial portion of the atmosphere was formed *before* the vapourous or aqueous portion.

The following passages will tend to show this :—

"Clouds consist of small hollow bladders of vapour charged each with the same kind of electricity. It is this electric charge which prevents the vesicles from uniting together, and falling down in the form of rain. Even the vesicular form which the vapour assumes is probably owing to the particles being charged with electricity. The natural repulsion of the electric particles may be considered as sufficient (*since they are prevented from leaving the vesicle by the action of the surrounding air*, and of the surrounded vesicles) to give the vapour the vesicular form."*

* Dr. Thomson on Electricity and Heat, p. 440.

"That clouds and mist consist of hollow vesicles, is further proved by the circumstance of their specific gravity being such, *that they remain suspended in the air*, without any tendency to descend, and even on frequent occasions are seen to ascend; whereas, if they consisted of round drops, without any internal vacuity, their descent would be rapid. Water is 828 times heavier than air; and it has been calculated that a drop whose diameter is no more than 1-1000th of an inch would acquire a descending velocity of nine or ten feet per second. . . . . .

"It might be supposed, that *the atmospheric compression would prevent the aqueous particles from originally assuming the vesicular form. But be it recollected that this is only one force acting against another. Without the compressing force of the external air*, the mutual repulsion of the particles of surplus electricity would distend the vesicles, until they burst from the thinness of their coating. Hence, *the atmospheric compression may be* conceived to be the cause which counteracts the mutual repulsion of the particles of surplus electricity so as to limit the distension of the vesicles to the dimensions previously stated. . . . . .

"It is obvious, *that the aqueous vesicles comprising clouds must, by some means or other, displace an amount of air, the weight of which is exactly equal to their own weight*. If they displaced more, their specific gravity would be less than that of the air by which they were surrounded, and they would consequently ascend to a higher altitude; if they displaced less, their specific gravity would be greater than the air by which they were surrounded, and they would accordingly descend to a lower level. . . . . .

"There is, therefore, no other way of accounting for the specific lightness of the aqueous vesicles than by supposing that they, by some means or other, *prevent the aerial particles approaching so near their surfaces as the particles of air do to each other*. But how this effect is produced it is not easy to conceive . . . . . . But judging from the fact, that the different denominations of clouds often float for a length of time at the altitude in the atmosphere where they are formed, without any apparent tendency to ascend or to descend, it may be concluded, *that the original specific gravity of the vesicles of which they are severally composed, is determined by the density of the atmosphere where they are formed*. If it be admitted that the vesicular shape is produced by the mutual repulsion of the particles of electricity evolved during the precipitation and conversion of invisible vapour into mist or cloud; and if it be admitted *that the atmospheric compression is the force which prevents the distending of the vesicles till they burst*, it is obvious, *cetera paribus*, that the distension of the vesicles and the thinness of their particles will be greater, and their specific gravity less, according *as the air is less dense at the place where they are formed*, and hence the specific gravity of the vesicles composing clouds will be proportioned *to the density of the atmosphere at the time and place of their formation*."*

The following corroborative evidence is from Dr. Thomson's recent introductory treatise on this complicated branch of philosophical study :—

"According to Halley," observes that writer, "the vesicles of fogs are hollow. From the optical phenomena presented and explained by Kratzenstein, there seems no reason to doubt the correctness of this opinion. Pro-

* Principles of Meteorology, by G. Hutchinson, pp. 152, 155, 158, 160, 164.

fessor Käuntz gives to these vesicles a mean diameter of 0.0224 millimeter, or nearly 1-1250th of an English inch. He has found that the season influences their size; thus they are twice as large in winter as in summer, the maximum being from December to February inclusive, and the minimum in May and August, the smallest being found in the latter month. The humidity of the atmosphere was observed to modify their magnitude. Drops of water are mingled with these hollow globules. . . . . . Clouds differ from fogs in their altitude and suspension, but in composition they are alike, having these ultimate constituents for their ingredients. Of their mode of suspension, their specific gravity being lighter than that of air, some have received this as a satisfactory explanation, but it is far from being cogent. Professor Stevelly, of Belfast, offers a theory, combining the gravitating force of the vesicles, which through their extreme minuteness is exceedingly trifling, with an electrical hypothesis to be immediately referred to. A far more plausible theory attributes it to currents, upward and horizontal. Another hypothesis assigns it entirely to electrical agency. We know that electricity has much to do with the phenomenon; it is largely developed during evaporation, as was long ago shown by Volta, Saussure, Lavoisier, La Place, and Bennet, and the vapour acquires that form denominated *positive*, while the water which remains is *negatively* charged, terms arbitrary but convenient, indicating *one* electricity in one or other of its separate conditions. . . . . . In whichever state the electricity exists in clouds in the aggregate, there will be a repulsion and attraction of the particles, by virtue of the law, that bodies similarly electrified repel, while those in the opposite electric state attract each other. It is easy to conceive that this electricity accumulates around the individual molecules, and prevents the coalescence of the vesicles into drops, the specific gravity of which would cause their precipitation. Thus they are buoyed in the air till other influences cause their descent."*

An attentive perusal of these passages (some of which I have taken the liberty to put in italics), and a reference, if needful, to any other treatise on meteorology, will convince every one, that no *rationale* of the phenomena connected with this department of nature can be attempted without assuming the pre-existence, in the *order* of time, of the aerial body of the atmosphere; not only for the suspension of the aqueous vesicles when once formed, but as indispensable towards their *original formation.* The air, itself, being one of the equipoising forces, by whose action, on the aqueous vapour, these very vesicles are formed; heat and electricity *within* causing their distention into the vesicular construction, the atmosphere *without* restraining these humid globules from destructive explosion, and regulating their form and specific gravity by its own density or pressure.

These multiplied effects are, evidently, the result of one single law, "Let there be *a* firmament in the midst of the waters, and let *it* divide the waters from the waters." The formation and coalescing of these congeries of vesicles enabling them to float in the air, in all their varied and attractive forms, while executing the important

* Introduction to Meteorology, pp. 115, 123, 124.

services for which they were, at the proper juncture, called into existence; whilst the wisdom and benignity of the Creator is shown forth in their never-ending change and beauty of form, the splendour of their reflected colours, and in the welcome refreshment which they bring to the parched earth, and to its fainting inhabitants.

At the same time, the fact must not be overlooked, that unless there had co-existed the elements of moisture, and of heat, or electricity, the aerial ocean above would have been a barren, unproductive waste of dry air, floating around, scorching and drying up everything with which it came in contact; "the heavens would have been as molten brass over our heads." The union of these separate formations, and the peculiar way in which they are connected; the one permeating the other, and acted upon diversely by the same cause, heat, seem as essential to the perfection of the whole, as was the aerial body in which the vesicles of moisture float; without this atmosphere, even although moisture, heat, and electricity had existed, there never could have been a single aqueous globule brought into visible form; lacking this initial and important component of clouds and mists, we should have been deprived of the requisite meteorological machinery, so indispensable for the transference, from the ocean to the land, of those refreshing showers with which all departments of organic nature are now so opportunely blessed. No deduction from admitted premises can be more clear or logical than this. It is the natural consequence of the announcements of philosophy. The aerial ocean first; the aqueous associate afterwards; while the whole tenor of the Mosaic narrative is equally clear and conclusive to the same effect.

On reviewing the simply told, but wonderful account of the formation of the atmosphere, and especially, when it is considered in relation to the findings and declarations of philosophy, we cannot avoid being struck by the effective simplicity and comprehensiveness of the physical laws which are recorded to have been thus impressed on the component elements then present, whereby the atmosphere was called into existence. Every attempt to explain the vicissitudes of the weather concurringly show, that there exists a certain ratio of variation (whose rule, although very nearly discovered, has not yet been absolutely determined) in the influence which the atmosphere exercises in producing those vicissitudes, according to the temperature, altitude, and density of that great aerial body.* And no single law more capable of producing such diversified results can be conceived than that described in this portion of Scripture, "Let there be a firmament in the midst of the waters, and Let *it* divide the waters from the waters." For, in this we behold a uniform power, the primary light, made to coalesce with a mass, the water of the first day, whose density, and therefore whose capacity

* Wells, Whewell, Graham, Thomson, and Hutchinson.

for the light, heat, or electricity which had been put into active operation, varied according to its altitude, and consequently the resultant power or body would still have diversified influences according to *its* density or altitude. An equal quantity, added universally to an unequal mass, would still leave the entire mass unequal in its parts. It might result in the production of a *greater*, or of a *different* description of power, but nevertheless the original inequality would pervade the whole, and cause it to produce corresponding effects.

And, indeed, this was precisely what the firmament was designed to do; clouds, mist, dew, rain, snow, &c., and all the intricate machinery which produce those delightful and healthful vicissitudes of weather we enjoy, are all brought about by this varying power of the firmament, which at any given place, or at any supposable altitude, acts according to its constituent energy in those particular localities; modified, but not overcome, by the minor influences of land and sea, the diversity of surface, or of day and night; rendering it, thereby, almost impossible to deduce from data accumulated at any one point, what may be the results at any other, or even at the same point in succession of time, in consequence of the continuity of the aerial ocean, and the action and reaction which the climate and weather of one place produce on the climate and weather of another.

This closes the evidence intended to be brought forward from *this branch* of our subject, to assist in proving the fundamental assumption of the Dynamical Theory, namely, *that until the formation of the light, and its division from the darkness, the earth had no rotation around its axis.* No evidences, taken as a whole, could be more convincingly conclusive, so far as the one subject bears upon the other; indeed, had the philosophical part of the evidences been written for the purpose, in place of being quite unconsciously penned as regards this, they could not have been more direct, nor would they have left a more favourable impression upon the mind. To render more indelible the convictions these evidences afford, a recapitulation of their principal points, or leading features, and a comparison of them with the state of the globe at the period to which I allude, may be desirable, in order to show, that all the attendant circumstances were pre-arranged in the most appropriate manner, and with perfect wisdom, for the promotion of the operations then taking place.

The *expansive principle* was to be infused into, or introduced amongst the waters; and it was to divide the waters from the waters, by causing a portion of them to ascend. To facilitate the accomplishment of these two consecutive acts of divine will, the *attractive influence* which had formerly been exerted over the waters, was, for the time being, to a certain degree invaded by the counteracting influence of the centrifugal impetus impressed upon the

water by the rotation of the earth; it being quite obvious that a hollow sphere of water, such as then surrounded the globe, must have become much less dense when it increased its diameter, as the waters undoubtedly did, when raised up by the centrifugal impetus, whatever may have been the amount of the increment they underwent; and therefore, the waters which were to be divided by the expansion, in place of presenting a compact, and comparatively impenetrable body to the influence of the light, by being dispersed through a greater extent of space, were rendered more easy of combination with that subtile fluid; besides, by that operation, the primitive ocean was transformed into a body possessing greater differences of density within its own mass, and thereby made more to resemble the atmosphere, than had it remained, as it previously was, before the expanding influence of protorotation was impressed upon it.

The vast extent of surface, in consequence of the whole globe having been surrounded with water; and that surface being expanded by the action of the centrifugal impetus, was likewise particularly favourable for promoting vaporization, "the quantity of water which the ocean dismisses into the atmosphere being in proportion to the extent of surface;"* and again, "the quantity of vapour exhaled is greater where the surface is extensive, and this in proportion to the superfices."† The absence of the atmosphere, and, consequently, of its pressure, afforded an increased facility to the combination of the expansive principle with water equal to 124 degrees of Fahrenheit's thermometer.‡ "According to Robinson, fluids boil in vacuo at 140 degrees lower than in open air."§

In addition to these proofs of the wisdom which was exhibited throughout the whole of this important part of the Creator's work—the formation of "the glorious life-sustaining ATMOSPHERE"—there is to be added the facility of combination with the LIGHT, towards which all things seem at that particular period to have been made to conspire, and which would be greatly accelerated by the thrusting up, from beneath and into the water, of those immense masses of heated mineral materials which were simultaneously forming into our present continental ridges and mountain chains; also by the application of the combining principle in a *tangential* direction, as will presently be shown to have been the case; and by the absence of atmospheric pressure—it being declared by the announcements of modern philosophy, founded on experience, "*That the vaporization of a fluid is accelerated by the increase of temperature, and more so when heat is applied where the surface is free from external pressure. In a vacuum vaporization is almost instantaneous.*"‖

And, finally, the same design was materially aided by the absence

* Theorem 93 and evidences.
† Thomson's Meteorology, p. 101.
‡ Theorem 54 and authorities.
§ Thomson's Meteorology, p. 18.
‖ Theorem 95 and evidences.

of all previous watery vapour in the atmosphere, and the consequent tension arising therefrom; it being an axiom "that the general rate of evaporation will be in proportion to the tension of the vapour which would saturate the air, diminished by the tension of the vapour which is actually in the air." For "the more under-saturated the atmosphere is, the drier it is said to be; and the stronger is its influence in promoting evaporation from moist surfaces;"* and according to another writer, "*cetera paribus*, the rate of evaporation is inversely as the air's density."†

In short, it is scarcely possible, that any announcement whatever could have been more thoroughly in accordance with the facts brought to light, and established by the labours of systematic philosophy, than the declaration which has been put on record in the Word of Truth, thereby evidencing the most undeniable traces of design in the formation, arrangement, and union of all the elements employed in producing the work itself; while the facility which was afforded, by every step in the process, for instantaneous vaporization, harmonises, in the most concurrent manner, *with the shortness of the period* assigned in the Mosaic narrative for its performance. *A whole atmosphere saturated with moisture during part of one day* could hardly be conceived, according to natural causes, without the remarkable concurrence of all those circumstances favourable for its promotion, which have just been shown were cotemporaneously present at the period alluded to, whilst the same evidences likewise establish beyond the possibility of a doubt, that the formation of the atmosphere took place at the TIME mentioned by the inspired historian, *when there was a concurrence of circumstances favourable to its formation, which have never since presented themselves, nor, as far as is known, were ever present together at any time before.*‡

The design of the Creator in forming NITROGEN by the instrumentality of myriads of invertebrate apulmonic animals, during innumerable ages, affords a most remarkable glimpse into the arcanæ of the creation. It evinces, in a manner which admits of no misunderstanding, that while their stony exuviæ were made instrumental in forming the solid crust of the earth, the nitrogen contained in the gaseous exhalations arising from the decomposition of their animal matter, was indispensably required to dilute the oxygen of the atmosphere to such a degree as should permit the respiration of animals and plants—and other operations common to the surface—to go on without combustion and destruction; thus appearing to indicate, that there existed some mysterious necessity, whereby *animals without lungs should secrete what was afterwards to enable animals with lungs, and plants with pulmonic appendages, to breathe*

* Principles of Meteorology, by G. Hutchinson, p. 17. † Thomson, p. 102.

‡ This is in perfect accordance with the fundamental basis of this *Theory*, namely, that God made all things; but that whatever is not specially mentioned in the first chapter of Genesis, was the effect of *natural* causes.—AUTHOR.

atmospheric air! More remarkable still; it may possibly have been, indeed it is almost certain to have been, that during these protracted ages, the subtile elements of which the ethereal fluid is composed were being elaborated, and ready to be transformed into physical light, whenever it should harmonize with the decrees of the Creator, to will the luminiferous fluid into existence; and to bring it to a state of perfection. And thereafter by dividing it from the darkness, to render it *the second great and effectual principle of the material universe!*—His chief agent during the six days' work of creation.

This is a conception well worthy of being wrought out, and, indeed, when the amazing tenuity and elasticity of this all-pervading fluid is taken into account, and considered that it is millions of times more tenuous in comparison with air, than air is when compared with earth, it seems more than probable that its bases had some such origin; and that it may have required a protracted period of darkness and non-rotation to have formed its elements.

Dr. Thomson seems to coincide in this opinion, and confirms it by the manner of stating his.

"Believing," says he, "that the atmosphere is composed of entities or ultimate atoms, it is evident that a limit does exist; for the force of gravity drawing each towards the earth's centre, must be greater than the repulsive power of the individual particles, in proportion to the density; and exactly where these forces balance, the extreme boundary will be found. Above this, probably an ether spreads through the planetary regions, meeting the upper limits of the atmospheres of other globes, and stretching forth to the remotest space. Mariotte discovered the law of atmospheric elasticity, that the density or volume of a given quantity of air is inversely as the pressure. Its density at any altitude may be easily found, for, as the elevation is increased in arithmetical progression, the density is decreased in geometrical progression. . . . . .

"Let us imagine," he continues, "a hollow sphere of such magnitude that the planet Saturn (whose distance from the sun is nearly 900 millions of miles) could perform its solar revolution within it. One single cubic inch of air, as rarefied at an altitude of 500 miles, would fill it entirely. That the eye may behold the vastness of this amount, we give it numerically, 3,053,635,200,000,000,000,000,000,000, or three thousand and fifty-three quadrillions six hundred and thirty-five thousand two hundred trillions of cubic miles, English notation."*

In the previous sections of this work it has been made manifest, that the materials which constitute the outer crust of the earth were, for ages, preparing under the water of the primeval ocean. And, in this, it has, in like manner, been demonstrated, that those which compose the firmament or heaven were also undergoing a similar preparation in the same element. On comparing these conclusions, which are founded on the undeniable evidence of philosophy, with the announcements of Scripture, which state, that "In the beginning God created the heaven and the earth," the strictest accordance will

* Introduction to Meteorology, pp. 23, 24.

be found to prevail between them; and they will therefore impress upon every unprejudiced mind the most perfect and reliable conviction of the soundness of the Dynamical Theory.

And this, happily, brings matters to a point which enables me to draw a conclusion which has long been desired, namely, having shown the truth of the Mosaic narrative in all that pertains to matter, with respect to which, tangible proofs, and evidences appreciable by the senses, can be made available, it is surely not unreasonable to insist—*That the inspired historian shall be credited, upon his mere assertion, with regard to the remaining and most important term of the whole passage, which admits of no tangible or philosophic proof whatever, namely, that they were all created and made by* GOD; *for he has also affirmed, that "In the beginning* GOD *created the heaven and the earth."*

SECTION VII.

COMPLETION OF THE ATMOSPHERE; SEPARATION OF THE SEA FROM THE LAND; AND THEIR IMMEDIATE COMBINED RESULTS.

CHAPTER XXXII.

First use made, by the Creator, of the newly-formed Atmosphere. Separation of the Sea from the Land. This separation effected by Vaporization. Numerous preparatory explanations and advertencies necessary for the effectual prosecution of our argument, and for the establishing of this fact. Different substances vaporized at diverse temperatures: scientific evidences of this. The effects of the application of heat to a solution of salt and water. Results which occur when different descriptions of salts, held simultaneously in solution, are allowed to crystalize; and, also, when these are associated with earthy materials. Concluding proofs on these two points.

The preceding chapter was almost exclusively dedicated to points connected with the introduction of the principle of *expansion* into the water of the primeval ocean; to the indissoluble union of this buoyant fluid with the ponderable elemental bases of the atmosphere, and the remarkable property which they possess, when so united, of spontaneously diffusing themselves throughout the regions of space, in opposition to the otherwise all comprehensive law of gravity; and, likewise, to the separation, from the great body of the water, of a certain portion thereof by means of the same expansive and buoyant influence, and its transformation into the more subtile watery vapour of the atmosphere. When conducting these several branches of enquiry I endeavoured to preserve a uniformity of design by showing, that these stupendous works of the Creator were not only thoroughly consistent with the principal features of this theory, but that the principles involved are indispensable towards a correct conception of the way in which those works were carried on and completed; the centrifugal impetus, of the first rotation, having been one of the secondary or natural agencies employed for the purpose.

In prosecution of the main argument, I shall now endeavour to render conclusive the evidences which may be procurable, from this particular branch of the subject, in confirmation of the original posi-

tion assumed, *the non-rotation of the earth, and its subsequent protorotation*, by showing that the *atmosphere* thus newly-formed and constituted, was chiefly instrumental in carrying out *the next great movement* in the progressive development of the plan of creation, namely—*the transference of the waters into one place; the restraining them at the level which they now maintain; and separating by the same process the saline ingredients from the water, and depositing them in the soil. And, that nothing but a world put into diurnal motion, for the first time, could have produced these effects.*

There can be no doubt, that when the firmament was formed, by its means and the influence of the centrifugal impetus, the waters were maintained at an elevation far above their present level, and even above the highest mountain chains; but it is likewise obvious, that although under such an impetus, whenever they had attained a state of equilibrium, they would, in obedience to the universal law of gravitation, from which they had been only temporarily abstracted, seek and resume their natural level; and, in doing this, had they been allowed to follow, what is now their *natural law*, they would have been *drained* off from the continental ridges into the oceanic hollows which had been prepared for their reception. But there is another truth which, in this case, stands as conspicuously forward, namely, that had this been permitted, a corresponding denudation of the new formed land must inevitably have taken place; and the greater part of its recently deposited soil and salts would irresistibly have been swept into the oceanic cavities, where they would not only have been of no use whatever, but would have been detrimental.

These observations must persuade every one that according to the laws which had been impressed on matter, up to the period now alluded to, VAPORIZATION, by means of the newly-formed atmosphere, was the method best adapted for separating the land from the water, without exposing the earth to denudation, and the ocean to be injured by being re-saturated with earthy sediment. To the complete establishment of this position the present section will be exclusively dedicated.

As the greater part of the last division was occupied in showing the fitness, at that period, alike of the condition of the atmosphere, and of the waters of the ocean, for promoting rapid or almost instantaneous vaporization, these truths need only now be applied to the case at present under consideration, in order to be convinced, that no arrangement could possibly have been better adapted for effecting the removal of the waters from the continents, and from those lands whose height rose above the then lower limits of the atmosphere; or, what is the same thing, *above the present level of the ocean.*

In conducting this investigation, we must distinguish with precision between the conditions of an atmosphere in the process of formation, and those of one actually constituted, as now experienced.

In the former case—that more immediately under consideration,—the elements of which it was being composed were in the act of emanating from the primeval ocean, and expanding themselves, with inconceivable rapidity and violence, into the regions of space, to the height of forty or fifty miles above their former level; and, consequently, relieving the evaporating surface from all pressure: or, in other words, accelerating the combination of the expansive principle with the elements of water and their associated gases, by an accession of force, according to some estimates, equal to one hundred and twenty-four degrees of Fahrenheit's thermometer, and of one hundred and forty according to the opinion of others. Besides, it is one of the best established axioms of pneumatics, "That the elastic force of any given portion of air is augmented in precisely the same proportion as the space within which it is enclosed is diminished."* This announcement may assist us to conceive the irresistible violence and velocity with which the body of the atmosphere would rush upwards from its state of *greatest possible reduction of space*, which it maintained when, as yet, its elements were in their most condensed form, before the light was introduced, or the earth had been made to revolve around its axis, to assume *its tension of equilibrium* in the static condition in which it now remains! Nothing similar to this sudden and violent rush of gaseous elements upwards and around can be imagined except it be the rush of waters which took place from the poles towards the equator, to complete *their* figure of equilibrium, or that of rotation, when the earth first revolved around its axis. In the latter case, centrifugal impetus alone occasioned their violent rushing motion. In that of the atmosphere, while the elements were assisted in their upward tendency, against the all-comprehensive law of gravity by the centrifugal force then brought into action, the simultaneous impartation to their ponderable bases of the buoyant principle of light, completed their impetus of ascension into the regions of space.

"Mariotte," says Dr. Thomson, as before quoted, "discovered the law of atmospheric elasticity to be, that the density or volume of a given quantity of air is inversely as the pressure."†

There is another important truth, derived from the study of meteorology, which should be borne in mind for the more thorough comprehension of the present argument; I allude to *the capability of the atmosphere to support, imbibe, or to become saturated with watery vapour*. This varies greatly *and increases rapidly according to the temperature;* indeed, so much is this the case, that Dr. Dalton found the amount and tension of vapour in the atmosphere to be altogether independent of the presence of the air, and to be wholly regulated by caloric. Dr. Thomson mentions a difference of range between 1-62nd and 1-80th of the volume of the air, but other

* Hydrostatics, Cab. Cyc. p. 237.

† Introduction to Meteorology, p. 23.

writers give much greater extremes.* These will serve to show the amount of the agency which might be imposed upon the firmament to produce *vaporization*, and to bear up and transport the vapour, especially when the former was in process of formation, and while as yet it exercised *a comparatively light pressure upon the evaporating surface, and was, itself of a high temperature.* The drier the atmosphere the greater is its influence in promoting evaporation from moist surfaces.

Keeping, therefore, these preliminary observations properly before the mind, let us endeavour to apply them to the elucidation of the present point, namely, *the vaporization of the water from off the surface of the land, and its transferrence, by means of the newly-formed atmosphere, into the waters of the ocean;* the assumption being, that the atmosphere† was the means whereby the Creator effected his purpose, without exposing the land to any of those prejudicial effects which, according to the laws of matter, would have ensued, had this ubiquous agent not been employed *to raise the water off the surface of the earth;* while as yet the upper part was in process of being formed into ferraceous soil by the oxidation of the elements then present, and by the comminution of the rocky masses brought into collision and abraded by the recent commotion, consequent on the protorotation of the earth; while the same aerial agency was employed to waft away the surplus water, and to deposit it in the sea. It can easily be conceived how essential such agency as this was to effect the double purpose of raising the water *off* the ground, in order that it might be rendered innocuous, and do no injury by denuding the land during its removal, while at the same time it was being carried most effectually, by the newly-formed atmosphere, to regions perpendicular to those hollows destined to be the receptacles of the world's wide oceans! There is something peculiarly sublime in the conception of operations so vast as these being effected by means so simply comprehensive and so effectual!

The glorious newly-formed atmosphere, ere it was polluted by the breath of a single mortal, becoming the willing, the powerful, and the effectual instrument of the designs of the Creator in forwarding the progressive development of His plans! No sooner is it fully formed, than it aids the completion of other portions of the work; draws up the surplus waters with inconceivable rapidity; separates them by infiltration from their saline associates, which were required where they had been thrown by the general revolution; and hurries the disassociated waters through aerial space, to let them drop where *they, too,* are required, in freshness and separation from their formerly commingled salts!

* Mr. Hutchinson says from 1-60th to 1-300th part, and in warm climates nearly double; and Professor Whewell considers that the proportion, in weight, which the *aqueous* bears to the *aerial* portions of the atmosphere, may vary according to circumstances from 1-100th to 1-20th of the whole aerial ocean.—(Bridgewater Treatise, pp. 96, 99.) See also "Philosophy of Storms."

† In Genesis called "the Heavens."

It may be well here to observe, merely as a memorandum to be afterwards referred to, that up to this period of the creation, there was no motion which, strictly speaking, could be considered *lateral.* Hitherto motion was either from the centre towards the circumference or from the circumference towards the centre. *Lateral* motion seems to have commenced with the command—"Let the waters be *gathered* together into one place." And well may the seas of the whole world be said to have been gathered into "one place." For however corrugated and diversified their *littoral* and their *under* surfaces may be, yet their *upper* surface, by having found and maintained a common level, shows that the waters under the heavens have all commingled, and occupy but "one place."

In prosecution of the more direct line of our discourse, the reader must now be made acquainted with what is stated in the *eighty-fourth* Theorem, respecting the upper boundary or limit of the atmosphere, "*whose density diminishes with extreme rapidity as it proceeds upwards, and eventually, at a height not exceeding fifty miles, reaches a real and definite boundary,*" *where there is no atmosphere.* "*And that this upper surface is estimated to be precisely where the specific elasticity of the air is balanced by the power of gravitation.*"

This theorem shows that the atmosphere has a definite boundary upwards; and as the earth and oceans form its bed or margin underneath, it follows, as a clear deduction, that whatever may have been the force or rapidity of its expansion when in the process of formation, the *direction,* owing to the inflexible nature of the materials constituting its *lower* boundary lines, *must have been upwards.* Taking, therefore, these circumstantials into account, we cannot fail to be convinced, that whenever it reached that point of static equilibrium, "where the specific elasticity of the air" became "balanced by the power of gravitation," *there must have ensued an immediate revulsion equal to the whole weight of the atmosphere.* So long as the atmosphere was expanding laterally and also rushing upwards, *there could have been no pressure whatever on the waters beneath;* but so soon as that upward and lateral tendency ceased, an opposite tendency on the part of the atmosphere, as a whole, must, in obedience to the previously existing laws of matter, have taken place. This may be expressed in other and perhaps more perspicuous terms by saying—that during the process of formation, the *ponderable* bases of the atmosphere, from the very fact of their being in the act of combining with the principle of expansion, were necessarily abstracted from the antagonistic force of attraction, until they had attained their static condition of buoyancy; and in this combined state were restored to the influence of attraction; the minute particles of ponderable matter, constituting the radicle or base, remaining in immutable combination with the elastic principle of light; but, as a whole, recognising, at the same time, the law of

gravity in precise proportion to the entire mass. This is expressed by Dr. Thomson (as already quoted) in the following words:—

"Believing that the atmosphere is composed of ultimate atoms, it is evident that a limit does exist; for the force of gravity, drawing each towards the earth's centre, must be greater than the repulsive power of the individual particles in proportion to their density, and exactly where their forces balance the extreme boundary will be found."

Reverting to the assumption, already advanced, that the surplus water was transferred from the "land" to the "sea" by *vaporization*, through the instrumentality of the recently-formed atmosphere, and to the extraordinary range of degrees to which the latter can be saturated with watery vapour, even from one hundredth to a twentieth part in weight, according to Professor Whewell, it may be assumed, as a matter of course, that on the present occasion the atmosphere was impregnated with moisture to its utmost capability. This, it is imagined, will be readily conceded. But the transference of watery vapour from *underneath* the level of the atmosphere into the atmosphere itself, that it might become its carrier; or what is the same thing, the loading of the atmosphere with a super-degree of watery vapour, to the extreme of what it would carry, is tantamount to the transference of ponderable matter from *beneath* the level of the atmosphere to a line *above* that level; and, consequently *would be equivalent to the exertion of a pressure by the atmosphere on the waters, corresponding to its increase of gravity.*

It will at once be perceived how conducive this pressure would be in forwarding the due development of the plan of creation, at the very point then in progress, inasmuch as it would contribute to restrain the ocean within the limits assigned to it; and by pressure make room for the very waters which were to be added to the seas, when that which existed as surplus vapour in the loaded atmosphere should be condensed into rain and added to the great oceanic mass.*

It is further assumed—on the principle "that matter can produce no spontaneous change, either in character or motion in itself"—an axiom often referred to in this treatise—that when the firmament or atmosphere had once reached a static condition of equilibrium—and that was certain to be the case in fulfilment of the laws conferred on its material nature—it could not of itself have changed a single iota; nor would the work of creation have been advanced a single degree further, unless it had pleased the Omnipotent to have,

* The description given by the Creator of that event, when speaking by the voice of another of His inspired historians, is so remarkable and illustrative, that I quote the passage, as corroborative evidence:—

"*Who,*" asks the Omnipotent of his afflicted but patient servant, "shut up the sea with doors, when it brake forth *as if* it had issued out of the womb? When I made the cloud the garment thereof, and thick darkness a swaddling band for it, And brake up for it my decreed *place*, and set bars and doors, And said, Hitherto shalt thou come, but no further; and here shall thy proud waves be stayed."—(Job xxxviii. 8—11.)

at this very juncture, issued a new decree, whereby the work was caused to progress. And when the state of the creation at the period referred to is taken into consideration, we shall find that it was the decree most essential, nay absolutely indispensable, agreeably to the general laws of matter and the particular condition of it, alluded to above; I mean its incapability of spontaneously producing alteration in itself. Hitherto there had been no *lateral* motion impressed on matter; its movements had been produced by either attraction towards the centre, or by centrifugal impetus *from* the centre towards the circumference; or by a composition of those two forces, as in the instance of the luni-solar current around the earth in the midst of the primeval circumfluent waters. While in the case under immediate consideration, if there had been no *new* command given; the waters which rose by vaporization from off the land and from intermixture with their former earthy and saline associates, would necessarily have fallen back again in the condition of rain—abundant rain, upon precisely the same spot from whence they arose; and would have re-entered into combination with the materials from which they had been, for wise purposes, disassociated. When we consider, too, the media into which this lateral movement was first introduced—*the atmosphere*—a body abstracted almost, as it were, from the influence of friction, we shall more fully recognise the wisdom of the succeeding decree—"Let the waters *under* the heaven be gathered into one place, and let the dry *land* appear." Every concomitant circumstance having, by the previous arrangements, been made favourable to the easy fulfilment of this command.

Assuming, therefore, *that the primary lower level of the atmosphere over the oceanic portion of the earth's surface*, with the slight difference of the increment occasioned by the water transfused into the ocean by the instrumentality of the atmosphere itself, *was that which at present it occupies*, it is obvious it must have been then, as it still is in many places, upwards of twenty, and in some instances even as much as twenty-seven thousand feet beneath the summit of the mountains; for, as the *eighty-fourth* Theorem expresses it:—"*The atmosphere is an aerial ocean surrounding the earth in all directions, and of which the surface of the land and sea forms the bed.*" We know that there are mountain ranges of this height which, although then but recently elevated, yet existed at their present elevation *before* the atmosphere was formed, and which now penetrate *upwards*, if I may so express it, from twenty to twenty-seven thousand feet *into* the aerial ocean in question: just as there are, on the other hand, oceanic hollows into which the waters penetrate many thousands of feet below the undermost aerial surface.

The admission of this fact, which is apparent to the *senses*, and subject to actual measurement, seems at variance with another equally well authenticated fact, although not so perceptible to the

senses, namely, that notwithstanding this great elevation of the mountain chains above the *undermost* level of the *atmosphere* there was no land discernible; or rather, there would have been no land discernible at that time had there been eyes to have searched for it. It was still enveloped by the primitive waters, and by their vaporous exhalations in the atmosphere, even after this had been completed, until the "waters under the heaven were gathered together into one place, and the dry *land* appeared."

The seeming opposition of these two branches of evidence, neither of which can be disputed, appears to involve this argument in so serious a difficulty, as almost to bring it to an abrupt conclusion. For, on the one hand, it has been admitted that there was an atmosphere which already divided waters which were *above* it from those which were *under* it, stretching from nearly the same *lower* level which at present it maintains on the bosom of the oceans, with entire continental chains of great collective elevation, and mountains towering even beyond these, all previously raised in solid stability; and yet, on the other hand, from implicit confidence in the announcements of *the only* authentic evidence to be found coeval with that period of the earth's history, it is maintained—*That not one of all those immense masses of mineral material, thrown up by the protorotation of the world was at all discernible,* or could have been perceptible had there then been a human eye in creation to have beheld it.

That which thus threatens to put so abrupt a termination to the progress of the argument, is intended to be made the chief means of proving the assumption at present contended for, namely, *That the waters were separated by* VAPORIZATION *from the land by means of the newly-formed atmosphere.* For, if after this latter part of the creation had been finished, there had been underneath it only an unbroken expanse of oceanic waters, this would have been a dilemma from which no human ingenuity or powers of reasoning could have extricated us, but the circumstance of the lower level of the atmosphere having been so many thousands of feet below some portions of the land, even when this was obscured by it, has left undeniable evidences, written in characters which cannot be misunderstood, *that the surplus waters were* EVAPORATED *from off the land, inasmuch as they have left a residium behind them which the atmosphere could not carry away with it;* but *which would not have remained, if "the waters,"* which were removed to admit of the "dry land" appearing, had *been drained from it into the oceanic hollows.* Fortunately, in favour of this there exists a body of evidence so strong, and so directly based on scientific research, and a chain of reasoning so complete, that nothing can withstand their combined influence.

In proof of this the first point to be attended to is part of the *ninety-fifth* Theorem, especially its latter clause:—"*That, in general, the rate of evaporation from the surface of the water, in all states of the*

atmosphere, will be proportioned to the tension of vapour which would saturate the atmosphere, diminished by the tension of the vapour actually in the atmosphere. And that, as different substances are subject to vaporization at different temperatures, this peculiarity is frequently employed in chemistry and the arts, as an efficacious method of precipitating solutions by separating them from the water with which they are combined."

As many evidences have already been adduced in support of the first part of this theorem, it is at present designed to exemplify, more particularly, the concluding portion, by the following apposite quotations from the scientific writers on whose *dicta* it is based:—

"Water," says Dr. Thomson, "at all temperatures, assumes the form of vapour. Evaporation proceeds from the snow-clad mountain and the glacier, as well as from the ocean and the meadow. Evaporation differs from Vaporization in the amount of heat required for its production. Water *vaporizes* when it passes into *steam* at a temperature of 212°; below that temperature it *evaporates*, passing into the ambient air in insensible moisture. . . . . . Besides other truths, Dalton has demonstrated that the elasticity of water at the boiling point under mean pressure, and that of our atmosphere at the same pressure, are equal; that aqueous vapour possesses exactly the same repulsive force in the atmosphere which it assumes in a vacuum, its temperature being the same,"* and so forth.

"If," observes Mr. Reid, "a few fragments of caustic potash be exposed to the air for a short time, they will become moist, softened, and liquid, in consequence of the moisture which they absorb from the air. . . . . . If the potash thus melted be heated strongly, the water may be boiled off, when the potash will be found in its former condition, dry, hard, and solid. Common pearlash, or the substance called chloride of calcium, may be used instead; a similar effect will be produced. . . . . . The chief cause of the presence of watery vapour in the air is the influence of heat, which, acting on the water of the seas, lakes, and rivers, in the world, is continually infusing the repulsive principle into them, and converting part of their surface water into vapour."†

"By such means," Dr. Lardner concludes, "the quantities of heat necessary to raise different bodies through the same range of temperature may be compared; and such a comparison presents the remarkable fact,"—which has been extensively availed of in the arts and manufactures to separate one substance from another—"*that every different body requires a different quantity of heat to produce in it the same change of temperature.*"‡

As there will be occasion almost immediately to bring forward proofs on a subject intimately connected with the whole of the *ninety-fifth* Theorem, whose evidences unavoidably blend together, the reader is referred to what may then be adduced, in addition to what has been said; and it is hoped these will be sufficiently explanatory and satisfactory: indeed, our every day household operations evince the different capacities for heat of water and of solids; this

* Introduction to Meteorology, p. 97.
† Chemistry, by Hugo Reid, pp. 53, 54.
‡ Heat, in Cab. Cyc. pp. 243, 263.

principle being invariably acted upon, although perhaps not chemically or scientifically understood.

The next thing to be done, is to bring the general truth, which has now been proven, to bear more closely upon the point desired to be established. For this purpose the conclusion is given as in the *fifty-eighth* Theorem :—" *That if heat be applied to a solution of salt and water, the repulsive force will cause the atoms of water to separate from the atoms of salt and carry the former away in pure vapour, while the salt will remain in the form of crystals; the same degree of repulsive force not being capable of overcoming the natural cohesion between its particles. That precisely similar results will ensue if a solution of the same material be exposed to vaporization; which, if continued for a sufficient length of time, will cause the water to disappear altogether, and leave a crystaline mass of salt behind.*"

The evidences of this theorem being essential they are given somewhat in detail :—

"The great reservoir of water," observes Mr. H. Reid, "from which all other kinds of water are, in the first instance, derived, is the ocean. In what way, it will be asked, can the water of rivers, lakes, springs, &c., be derived from the ocean? How is the salt water of the ocean converted into fresh water? The water of the ocean consists of a large quantity of common salt, and a few other matters. Now the water *(the pure water)* consisting solely of oxygen and hydrogen is very readily turned into vapour, even at the ordinary temperature of the air, and very abundantly in warm weather; while the salt and other matters, having a different relation to heat, do not readily pass into vapour, even at the highest temperature in the torrid zone. *Thus, the pure watery part of the ocean is turned into vapour and passes into the atmosphere, the salt and other matters being left behind; the sea water being thus decomposed by the effects of heat upon it.* . . . . . In order to procure water from any common spring or river water, there are two kinds of substances which must be got rid of before it is chemically pure, the gaseous matters which it contains and the earthy matters. . . . . The earthy matters are separated by the process of *distillation.* After the water has been boiled to expel all the gases which it may have contained, we continue to boil it, but cause the vapour or steam which comes away from it to pass into another vessel, in which it returns to the state of water. The heat applied to turn the water into vapour cannot convert into vapour the earthy matters which the water holds in solution; they remain behind, and are thus got rid of. The next vapours which come away are collected and condensed; they are the pure watery part."*

According to the principles of heat in the Cabinet Cyclopædia :—

"If salt be dissolved in water a chemical combination will be formed, composed of atoms of salt combined with atoms of water. Let such a solution be placed in a vessel B, closed at the top, and terminating in a tube carried to another vessel D, immersed in cold water. If boiling heat be applied to the vessel B, it will be found that the vapour produced will pass through the tube C, and be condensed into a liquid in the vessel D. After

* Popular Treatise on Chemistry, pp. 115, 116, 131.

this process has been continued for some time, it will be found that nothing but solid crystals of salt will remain in the vessel B, and the liquid contained in the vessel D will be pure water. If the masses of water and salt in the two vessels be weighed, their weights will be precisely the weight of the solution first placed in the vessel B. . . . . . A small quantity of salt of any kind dissolved in water causes the boiling point to rise higher than that of pure water. The steam has a less degree of elasticity than the steam of pure water, and does not contain a single particle of the salt dissolved in the water, nor any substance but pure water itself, which may be made manifest by condensing it in a separate vessel. . . . . . Evaporation being extensively used in the arts and manufactures, it is of importance to conduct it with as much economy and expedition as possible, the circumstances which principally promote it, being increase of temperature, and a constant change in the air which is immediately above the evaporating surface. These two objects have received special attention. In factories, where evaporation is used, the vessels containing the liquid to be evaporated are usually exposed to a current of air passing over their surface. In some cases to promote the evaporation by heating the liquid, the heat is frequently applied only to the surface, instead of being communicated by fire at the bottom of the vessel. In fact, the current of air which passes over the surface of the evaporating liquid is previously heated by forcing it through a fire. The flame of the fire is also sometimes made to play over the evaporating surface."*

"The general method," says Mr. Donovan, "of obtaining crystals from substances which dissolve in water is to add the substance to the water at a boiling heat, and in as great a quantity as the water is capable of holding in solution. As the liquor cools, the crystals are produced. Sometimes it will be necessary to reduce the liquor to the freezing point before it will crystalize; and sometimes the water requires to be gradually boiled away until the crystals have formed abundantly; it is in this way that common sea salt is crystalized. Motion promotes crystalization; but rest promotes regularity of the shape of the crystals."†

In continuation of the same chain of evidence, it will be necessary to ascertain what takes place when water, holding in solution the elements of *various descriptions* of salt, is subjected to the influence of evaporation. And it is satisfactory to find, that this and kindred subjects have received the closest attention from several chemists of the present day, on whose enquiries and chemical acumen every reliance may be placed. While it may not be uninfluential on subsequent reasoning, were it to be borne in mind, that when saline materials are held in combination by water, holding also earthy ingredients in suspension, and deposition takes place, *the salts are found invariably to crystalize almost in purity and separation from their associated elements; and to leave these to accumulate at the bottom, according as their specific gravities, or other attendant circumstances, may determine.*

"It is," observes Mr. Reid, "from its property of dissolving solid bodies, that water has the greatest claims on our attention. Various bodies, when

* Dr. Lardner, pp. 193, 207, 243, 244. † Chemistry, in Cab. Cyc. pp. 18, 19.

dissolved, manifest properties which we should never otherwise have been able to discover. Although water has a chemical attraction for a great many bodies, it has seldom a very strong attraction for them, and therefore does not alter their properties much, and seldom retains them with such a force as to prevent other bodies from acting upon them."

"It may," he continues, "be observed in the operation of solution, which is frequently performed for the purpose of *separating one substance from another, or from a number of others with which it may be associated.* Thus, the barilla from which soda is procured, contains the soda mixed with a quantity of other matters. The soda, however, is very soluble, while the others are insoluble, or nearly so; by lixiviation, then, the soda is extracted in solution, and the other matters are left in the solid state. The soda, however, has not a very great affinity for water, so that the latter readily leaves it in the form of vapour when heat is applied, and thus the soda is procured in the solid form. Water and heat are applied in this way to separate from each other various matters which may be mixed together, in a great many manufacturing processes, and many of the most useful articles which are used by man could not be procured without some such operation."*

"Besides the methods," says Dr. Murray, "of discovering the saline ingredients in mineral waters by re-agents which indicate their principles, they may by certain methods be obtained in their entire state, and their quantities determined. Evaporation is employed with this view, different substances being successively obtained as the evaporation is carried to a greater or less extent. Thus the carbonates of lime and magnesia are usually first precipitated, afterwards sulphate of lime falls down; if after these precipitations the liquor be drawn off and allowed to cool, the alkaline neutral salts and the sulphate of magnesia crystalize, while muriate of magnesia and muriate of lime, if present, will remain, forming an uncrystalizable residue."†

Having thus briefly shown that which usually takes place when water holding in solution *the elementary principles of salts* (without having taken into account the density of the earthy parts held simultaneously in mechanical suspension) is subjected to vaporization, it will now be shown, that when salts, by crystalizing, separate from their earthy associates, the latter fall down or are deposited in layers according to their specific gravities, or other attendant circumstances, or, in other words, in the inverse proportion of the power of the aqueous body to sustain them in suspension.

The following extracts, a part only of those which might be given, have reference to this subject:—

"Much of what goes on in the sea," observes Professor Phillips, "is entirely unknown to us. . . . . . How far into the sea currents of given velocity may transport sedimentary grains of given magnitude and specific gravity, is matter of calculation (Babbage); how far, in fact, the supernatant fresh waters can carry their earthy admixture, has been, in one instance, ascertained (River Amazon, Captain Sabine), ... but still it

* Popular Chemistry, pp. 109—111.

† Murray's Elements of Chemistry, vol. ii. p. 385.

is to the shores that we must ever turn for data to serve as bases for comparison between modern and ancient marine deposits.

"Here we see that the materials which the sea obtains from the wasting cliffs, rivers, and floods, are partly transported away by currents, and especially during storms, to considerable distances, but principally drifted coastways, and deposited in times of tranquillity. . . . . . In distributing the materials which fall from the cliffs, the agitation of the sea produces an effect of the same kind as the operation of washing a mixture of metallic ores and various spars, it separates the ingredients according to magnitude and specific weight; the heavy and large masses are left on the beach for slow distribution over the sloping surface or gradual descent into the deep; the coarse sand is urged onward by the tide, as a river pushes forward its bed, but the finer clays mix with the water, remain long suspended, and are carried to great distances, to be deposited wherever the sea stagnates, either by expansion, over level surfaces, or by opposition of the freshes.

"It is evident that the modern deposits of the sea are pebbly where the agitation is great, sandy where it is moderate, and argillaceous where it is little."*

"If," observes Mr. Lyell, in a passage already referred to in another part of this work, "we take a handful of quartzose sand, mixed with mica, and throw it into a clear running stream, we see the material immediately sorted by the water, the grains of quartz falling almost immediately to the bottom, while the plates of mica take much longer time to reach it, and are carried farther down the stream. At the first instant the waters are turbid, but immediately afterwards the flat surfaces of the plates of mica are seen alone reflecting a silvery light, and they descend slowly, to form a distinct micaceous lamina. It is easy, therefore, to conceive how the intermittent action of waves, currents, and tides may sort the sediments brought down from the waste of a granitic country, and throw down the mica, layer after layer, separately from the mud or sand."†

"The existence of the great and extensive operations," Prof. Playfair observes, "by which the spoils of the land are carried all over the ocean, and spread out on the bottom of it, may be supposed to require some further elucidation. We must attend, therefore, to the following circumstances. When the detritus of the land is delivered by the rivers into the sea, the heaviest part is deposited first, and the lighter are carried to a greater distance from the shore. . . . . . These are more easily carried to greater distances by being suspended in the water, from which they are gradually and slowly deposited. A remarkable proof of this is furnished from an observation made by Lord Mulgrave, in his voyage to the North Pole. About 250 miles off the coast of Norway he sounded with a line of 4,098 feet, and the lead, when it struck the ground, sunk in a soft blue clay to the depth of ten feet. The tenuity and fineness of the mud, which allowed the lead to sink so deep into it, must have resulted from the deposition of the lighter kinds of earth, which, being suspended in the water, had been carried to a great distance, and were now, without doubt, forming a regular stratum at the bottom of the sea."

In continuation, he observes, with his accustomed propriety of style—

* Treatise on Geology, pp. 202, 203. † Elements of Geology, vol. i. pp. 31, 32.

"Amid all the revolutions of the globe, the economy of nature has been uniform in this as well as in every other respect, and its laws are the only things that have resisted the general movement. The rivers and the rocks, the seas and the continents, have been changed in all their parts; but the laws which direct these mutations, and the rules to which they are subject, have remained invariably the same."*

Having thus traced, by these progressive steps, the changes which take place when water is drivon off by vaporization, and separated from whatever earthy or saline ingredients it may have been associated with; and shown how the earths, clays, and other mineral materials are deposited from water, when borne by it in mechanical suspension; both of which circumstances of condition it is considered took place during the first three days of the earth's rotation, when the rushing agitated ocean was plentifully charged with saline material and with earthy debris; it may be considered that the mind is in a position to go on, in a succeeding chapter, with the general argument.

* Playfair's Works, vol. i. pp. 407—415, Huttonian Theory.

SECTION VII.

COMPLETION OF THE ATMOSPHERE, &c.

CHAPTER XXXIII.

Opening advertency. During the juncture of protorotation immense masses of mineral *debris* mixed with saline materials spread abroad, and separated, within a few hours, from the water which held them in suspension. The Dynamical Theory requires that this separation should have taken place by VAPORIZATION. This fully borne out by the deposits of native salts, and confirmed by geological evidences, especially those having reference to the saliferous and gypseous associates of the New Red Sandstone and Oolitic formations. In continuation: several advertencies as to the way in which are to be viewed the operations then taking place; their order of sequence; the description of *forces* which prevailed: and the order in which they, too, were introduced into the universe. Indispensable utility of *lateral* motion in the formation of clouds, or in "gathering together" the nephalic masses of the atmosphere. And, in conclusion, scientific proofs.

THE several detached, but requisite investigations, which have almost exclusively occupied the attention in the preceding chapter, must now be applied in furtherance of the principal argument. Before doing so, however, it is requested, that what has been stated at the conclusion of the twelfth and commencement of the thirteenth chapters, relating to saline and acidulous ingredients held in solution by the primeval water towards the close of the non-rotatory period; together with that portion of the fifth section which treats of the New Red Sandstone formations, may be carefully re-perused; they will be found to be intimately connected with the present subject, and essential to its development. Considering these suggestions to have been complied with, attention is requested to the prefatory reasoning contained in the following brief argument.

During the elevation of the continents, an immense body of heterogeneous *debris* was spread abroad, and mechanically diffused throughout the surrounding waters which held saline and acidulous ingredients in chemical solution; and these waters thus saturated were, within twenty-four hours thereafter, separated from the land; an operation which must have been effected either by *draining off* the water, or by *vaporization*, natural means in either case having been permitted to operate. Under such combination of circum-

stances, it is required to know, what would have been the probable results of the process by each of these distinct methods of separation? And which is most accordant with the appreciable results remaining to the present day?

On the supposition of its having been effected by *drainage*, it is conceived, firstly, that it could not have been accomplished *within the time specified*, by any natural means which are now known; secondly, that both the earthy and the saline materials would have been simultaneously swept into the bed of the ocean; and, thirdly, that there would have remained no indurated saline or gypseous deposits of any extent. For, considering the land to have had the same form which it now has, wherever the nature of the ground impeded the escape of the waters requisite to have formed these deposits, the drainage of the present times still constitutes reservoirs of water, and consequently no dry residium could have been formed; and therefore could not now exist.

But, on the other hand, it is conceived, that if *vaporization* was employed to separate the heterogeneous mass of water, earths, and salts from each other, and the like laws, which are still in operation, operated *then*, their precipitated remains should be found associated together, according to the manner in which such combined ingredients usually separate when they are being deposited. That although the rapidity, with which the vaporization was effected, might have prevented them from assuming a perfect horizontality of position, they should, in general, be found pretty near a level, stretching over plains, at the bottoms of hills, and filling up hollows. That in obedience to the laws affecting the application of heat to a solution, in order to occasion vaporization, the water would be driven off; but the earthy and saline sediments, in consequence of not yielding to the same degree of heat, would solidify and remain in crystaline forms. That in accordance with the chemical affinities manifested by various salts, earths, and acids held in common solution, during the process of separation by vaporization, distinct deposits should be found of these salts and other substances, produced by the modifying influences above mentioned. And lastly, that as the salts, which were separated from their earthy associates in the act of crystalization, underwent distinct precipitation, alternate layers of salt and earth should be found occupying the places where such operations took place.

Having come to those conclusions by reasoning *a priori*, it is only now requisite to ascertain what is the experience of geologists founded on actual research. For, if the assumptions come to be correct, deposits of saline ingredients associated with gypsum, commensurate to the extent of the elements employed, should be discovered in and amongst the wide-spread ranges of formations classed under the designations of the New Red Sandstone, the Oolitic, and the Cretaceous groups, and even in some of the older members of

the Tertiary deposits, because these are they which, according to this theory, were formed by the deposition of the debris arising from the earth's first rotation. That the findings of geologists are perfectly accordant with this, and that these saline and gypseous deposits have hitherto baffled all endeavours to account for their existence, are points plainly proven by the *hundred and eighth* Theorem, "*That native salts, such as saltpetre, green vitriol, rock salt, sal ammoniac, borax or tincal, alum, and natron, are found fossil in the earth in regular and symmetrical crystaline forms.*" Whilst, without going into any of its evidences, in consequence of the subject being so rudimentary, I shall again refer to and repeat the *thirty-second* Theorem, which bears more directly on the point in question, "*That the formation called the* NEW RED SANDSTONE GROUP *is considered to be of mechanical origin and of heterogeneous composition; containing different kinds of fossil salts associated with gypsum, and much conglomerate and breccia. That, conjointly with the oolitic group, it frequently contributes to form extended tracts of level land, having aided in filling up immense hollows on the earth's surface at a time when, or immediately after, this latter had undergone a great and widely-extended revolution in its physical form, and in the condition of its vegetable and animal life. And that although most usually the deposits of rock salt are associated with the strata of the new red sandstone formation, yet they are not unfrequently found in the oolitic, cretaceous, and even in the tertiary formations.*"

As this, and the evidences connected with it, were, as far as possibly consistent with the argument, intentionally deferred, when treating of the geological division of the subject, it will be requisite now to go into them somewhat in detail, and scarcely any set of proofs, in the whole course of this treatise, will be found more convincingly conclusive than they are in favour of the position now sought to be established, namely, *that the water was separated from the land by vaporization*, and that this could have been effected only during a period when all those concurring circumstances were simultaneously present; while this remarkable concurrence was, in turn, the immediate offspring of the *first rotation of the earth around its axis.*

I shall commence with that which is given in the mineralogical illustrations of the Cuvierian theory:—

"The gypsum formation," observes Professor Jamieson, "is not entirely of gypsum, but contains also beds of clay, marl, and calcareous marl. These are arranged in a determinate order when they all occur together, which, however, is not always the case. They lie over the coarse marine limestone; and the gypsum, which is the principal mass of the formation, does not occur in widely-extended plateaus, like the limestone, but in single conical, or longish masses, which are sometimes of considerable extent, but always sharply bounded. Montmartre presents the best example of those around Paris, and there, three beds of gypsum are to be observed superimposed on each other.

"The *first* consists of alternate layers of gypsum, solid calcareous marl, and of thin slaty argillaceous marl or adhesive slate. . . . . . The *second bed* resembles the first, and only differs from it in being thicker, and containing fewer beds of marl. . . . . . The *third* or *upper bed* is by far the greatest, being in several places more than sixty feet thick. It contains few beds of marl, and in some places, as at Montmorency, it lies almost immediately under the soil. . . . . . The whole of these beds, from the layer immediately over the marine limestone, to that containing the oysters, constitute the gypsum formation. Cuvier considers them as constituting two formations, viz., the gypsum and marine marl formation."*

M. de la Beche supplies the next evidence to be brought forward respecting these saliferous deposits—

"M. Elie de Beaumont observes, that in many countries the variegated marls can scarcely be separated from the lias sandstone, for they appear to become one deposit, as in the environs of St. Leger-sur-Dheune, and Autun, and in the *arkose* of Burgundy. Masses of rock salt occur in the lower part of the marls at Vie, Dieuze, and other parts of that district; and masses of gypsum are found in the upper and lower portions, but principally in the latter. . . . . . It is impossible to close this sketch of the supra-cretaceous rocks without noticing the important observations of Dr. Boné on those of Galicia, wherein he establishes the fact, that the celebrated salt deposit of Wieliczka constitutes a portion of the supra-cretaceous series. Dr. Boné describes this deposit as 2,560 yards long, 1,066 yards broad, and 281 yards deep. The salt is termed green salt in the upper part of the mine, where it occurs in nodules with gypsum in marl. The salt sometimes contains lignite, bituminous wood, sand, and small broken shells. In the lower part the marl becomes more arenaceous, and there are even beds of sandstone in the salt. Beneath this is a grey sandstone, rather coarse, containing lignite, and impressions of plants, with veins and beds of salt. In the lower part of this stratum an indurated calcareous marl is observed, containing sulphur, salt, and gypsum. Beneath this is an aluminous and marno-argillaceous schist. From the fossils and various other circumstances, Dr. Boné concludes, that this great salt deposit forms part of a muriatiferous and supra-cretaceous clay, subordinate to sandstone (molasse). Most frequently the marly clays are merely muriatiferous; an abundance of salt, such as at Wieliczka, Bohemia, Parayd, in Transylvania, and other places, being more rare. . . . . . The red or variegated marls, which surmount the muschelkalk, possess a common mineralogical character over very considerable surfaces, such as would lead us to suppose some cause or causes exerting an influence of a similar kind over a large area. At least some of the deposit would appear chemical, more particularly the masses of gypsum and rock-salt which exist in certain situations."†

Professor Phillips, when treating on the same department of geological research, thus expresses himself:—

"The irregular expanse of sea left in the region of Europe by the broken masses of land, belonging to the uplifted carboniferous rocks, was perhaps not fully filled by the next succeeding deposit of sandstones, clays, and

* Jameson's Illustrations of the Cuvierian Theory, pp. 411—416.
† Manual of Geology, pp. 390, 246, 409.

limestone, which receives the name of red sandstone, or saliferous or poecilitic formation, but it is very extensively diffused in and beyond this area. . . . . . Salt is associated with the upper parts of this system in England, France, and Germany, where the muschelkalk is quite as saliferous as the variegated marls, to which apparently, salt is confined in England.

"Upon the whole, then, this red sandstone system is a vast mass of sandy and argillaceous sediments of a peculiar aspect, accompanied more than any others yet known by salt and gypsum, generally deficient in organic remains, and only locally inclosing strata of limestone, which commonly are characterized by abundance of magnesia. . . . . . Several reasons might be adduced to justify an opinion, that the time occupied in the production of the whole system was comparatively short, such as the general uniformity of its composition, the deficiency (except in limited regions) of limestones; the peculiar chemical and mineral character of these limestones; the general paucity of organic remains; the frequency of conglomerates, and local admixtures of fragments of igneous rocks; all these circumstances seem to indicate the predominance of an unusual series of agencies."*

Mr. Lyell, though very succinct with respect to the saliferous formations, supplies the following pointed evidence:—

"The term saliferous marl and sandstone," he observes, "has been applied to the upper new red system, because it is in this group that rock salt and salt springs occur in Cheshire and other parts of England, where the alternating beds of red and green marl, gypsum, and rock salt sometimes exceed 600 feet in thickness. The gypsum is generally fibrous, and intercolated very irregularly between the laminated argillaceous beds. The rock salt is sometimes clear and white, but is usually reddened by the argillaceous sediment with which it is associated. At Northwich, in Cheshire, are two beds of solid rock salt, which are, together, not less than 60 feet in thickness. The origin of these vast deposits of muriate of soda is still one of the most obscure problems in theoretical geology."†

"Hitherto," observes the illustrator of the Huttonian Theory, "we have enumerated those fossils that are either not at all, or very sparingly, soluble in water. There are, however, saline bodies among the mineral strata, such for instance as rock salt, which are readily dissolved in water; and it yet remains to examine by what cause their consolidation has been effected. . . . . . If the theorists who consider water as the sole agent in the mineralization of fossils refuse to call to their assistance any other than their favorite element, they will not find it easy to answer this question, and must feel the embarrassment of a system, subject to two difficulties, so nicely, but so unhappily adjusted, that one of them is always prepared to act whenever the other is removed. If, on the other hand, they will admit the operation of subterraneous heat, it appears possible, that the local application of such heat may have driven the water, in vapour, from one place to another, and by such action often repeated in the same spot, may have produced those great accumulations of saline matter that are actually found in the bowels of the earth. But granting that either in the way just pointed out, or in some other that is unknown, the salt and the water have been separated, some further action of heat seems requisite, before a compact

* Treatise on Geology, pp. 119, 123, 129.
† Elements of Geology, vol. ii. pp. 90, 91.

and highly indurated body like rock salt could be produced. The mere precipitation of the salt, would, as Dr. Hutton has observed, form only an assemblage of loose crystals at the bottom of the sea, without solidity or cohesion; and to convert such a mass into a firm and solid rock, would require the application of such heat as was able to reduce it into fusion. The consolidation of rock salt, therefore, however its separation from the water is accounted for, cannot be explained but on the hypothesis of subterraneous heat. Some other phenomena that have been observed in salt mines, come in support of the same conclusion. The salt rock of Cheshire, which lies in thick beds, interposed between strata of an argillaceous or marly stone, and is itself mixed with a considerable portion of the same earth, exhibits a very great peculiarity in its structure. Though it forms a mass extremely compact, the salt is found to be arranged in round masses of five or six feet in diameter, not truly spherical, but each compressed by those that surround it, so as to have the shape of an irregular polyhedron. These are formed of concentric coats distinguishable from one another by their colour, that is, probably by the greater or less quantity of earth which they contain, so that the roof of the mine, as it exhibits a horizontal section of them, is divided into polygonal figures, each with a multitude of polygons within it, having altogether no inconsiderable resemblance to a *mosaic* pavement. In the triangular spaces without the polygons, the salt is in coats parallel to the sides of the polygons. . . . . . It is clear that the whole mass of salt was fluid at once, and that the forces, whatever they were, which gave solidity to it, and produced the new arrangement of its particles, were all in action at the same time. The uniformity of the coated structure is a proof of this, and above all, the compression of the polyhedra, which is always mutual, the flat side of one being turned to the flat side of another, and never an angle to an angle, nor an angle to a side. The coats formed as it were round so many different centres of attraction, is also an appearance quite inconsistent with the notion of deposition; both these, however, are compatible with the notion of solidity acquired by the refrigeration of a fluid, where the whole mass is acted on at the same time, and where no solvent remains to be disposed of after the induration of the rest. Another species of fossil salt, the Trona of Africa, exhibits appearances equally favourable to the theory of igneous consolidation. . . . . . It contains but about one-sixth of the water of crystalization essential to this salt when obtained in the humid way; and, what is particularly to be remarked, it does not lose this water, nor become covered with a powder, like the common alkali, by simple exposure to the air. It is evident, therefore, that this fossil does not originate from mere precipitation; and when we add, that in its sparry structure it contains evident marks of having once been fluid, we have little reason to entertain much doubt concerning the principle of its consolidation. Thus, then, the testimony given to the operation of fire, or heat, as the consolidating power of the mineral kingdom, is not confined to a few fossils, but is general over all the strata."*

To conclude the evidences respecting these vast and widely-spread deposits of *native salt*, those undeniable memorials of the transformation of a watery-bound sphere into a terraqueous globe, I shall give an extract (which it is to be regretted the object of this work

* Illustrations of the Huttonian Theory, pp. 52—56.

obliges to be abridged) of the enlivening description with which Mr. Miller has favoured us, of the salt works at Droitwich:—

"The prevailing geological system in this part of England," he observes, "is the new red sandstone, upper and lower. It stretches for many miles around the Dudley coal basin, much in the way that the shires of Stirling and Dumbarton stretch around the waters of Loch Lomond, or the moors of Sutherland or the hills of Inverness-shire encircle the water of Loch Shin or Loch Ness. . . . . . The lower division of the new red is unimportant, but its upper division is not greatly inferior in economic value to the coal measures themselves. It forms the inexhaustible storehouse of our household salt, all that we employ in our fisheries, in our meat-curing establishments for the army and navy, in our agriculture, in our soda manufactories, all that fuses our glass, and fertilizes our fields, &c. . . . . . By pursuing southwards, for seven or eight miles, the road which, passing through Hales Owen, forms the principal street of the village, and some five or six miles further on, we reach the town of Droitwich, long famous for its salt springs. There were salt works there in the times of the Romans, and ever *since* the times of the Romans. . . . . . Droitwich was altogether, as I saw it, a sombre looking place; and what struck me was, that from this dark centre there should be passing continually outwards waggons, carts, track-boats, barges, all laden with pure white salt, that looked in the piled up heaps like wreaths of drifted snow. There could not be two things more unlike than the great staple of the town, and the town itself. . . . . . As I saw the vats seething over the furnaces, some of them already more than half-filled with the precipitated salt, and bearing atop a stratum of yellowish coloured fluid, the grand problem furnished by the saline deposits of this formation rose before me in all its difficulty. Geology propounds many a hard question to its students. . . . . . Here, now, are these briny springs welling out of this upper new red sandstone of central England, springs whose waters were employed in making salt two thousand years ago, and which still throw up that mineral at the rate of a thousand tons apiece weekly, without sign of diminution in either their volume or their degree of saturation. At Stoke Prior, about three miles to the east of Droitwich, a shaft of about four hundred and sixty feet has been sunk in the upper new red, and four beds of rock salt passed through, the united thickness of which amount to eighty-five feet. Nor does this comprise the entire thickness, as the lower bed, though penetrated to the depth of thirty feet, has not been perforated. In the salt mines of Cheshire, the beds are of still greater thickness. . . . . . And in Poland and Spain there occur salt deposits on a larger scale still. The saliferous district of Cordova, for instance, has its solid hills of rock salt, which nearly equal in height and bulk Arthur's Seat taken from the level of Holyrood House. How, I enquire, were these mighty deposits formed in the great laboratory of nature? Formed they must have been, in this part of the world, in an era long posterior to that of the coal; and in Spain, where they belong to the cretaceous group, in an era long posterior to that of the oolite. They are more immediately underlaid in England by a sandstone, constituting the base of the upper new red, which is largely charged with vegetable remains of a peculiar and well marked character; and the equally well-marked flora of the carboniferous period lies entombed many hundred feet below. All the rock salt in the kingdom must have been formed since the more

recent vegetation of the red sandstone lived and died, and was entombed amid the smooth sands of some deep sea bottom. But how formed? Several antagonistic theories have been promulgated in attempted resolution of the puzzle. By some the salt has been regarded as a volcanic product ejected from beneath; by some, as the precipitate of a deep sea overcharged with saline matter; by some, as a deposit of salt water lakes cut off from the main sea. . . . . . It seems fatal to the first theory, that the eras of plutonic disturbance in this part of the kingdom are of a date anterior to the era of the saliferous sandstone. The Clent Hills were unquestionably thrown up, many ages ere the saliferous era began. Volcanoes in the neighbourhood of the sea deposit, not unfrequently, a crust of salt on the rocks and lavas that surround their craters; but we never hear of their throwing down vast saliferous beds, continuous for great distances, like those of the new red sandstone of England. And further, how account for the occurrence of a volcanic product, spreading away in level beds and layers, for nearly two hundred miles, in one of the least disturbed of the English formations, and forming no inconsiderable portion of its strata? As for the second theory, it seems exceedingly difficult to conceive how, in an open sea, subject, of course, like all open seas, to such equalizing influences as the ruffling of the winds and the deeper stirrings of the tides, any one tract of water should become so largely saturated as to throw down portions of its salt, when the surrounding tracts, less strongly impregnated, retained theirs. . . . . . And the lagoon theory, though apparently more tenable than any of the others, seems scarce less enveloped in difficulty. The few inches, at most the few feet, of salt which line the bottoms and sides of the lagoons of the tropics, are but poor representatives of deposits of salt like those of the upper old red of Cheshire; and geology, as has been already indicated, has its deposits huger still. Were one of the vast craters of the Moon, Tycho, or Copernicus, to be filled with sea water to the brim, and the fires of twenty Ætnas to be lighted up under it, we could scarcely expect, as the result, a greater salt making than that of Cordova or Cracow. A bed of salt a hundred feet in thickness would demand for its salt-pan a lagoon many hundred feet in depth, and lagoons many hundred feet in depth, in at least the present state of things, are never evaporated."*

These evidences, which have been given at considerable length, conclusively prove, by means of the tangible monuments of what did then occur, that sudden and simultaneous VAPORIZATION must have taken place over all the continents, at a period when they were immersed in saline and acidulous water, holding, almost universally, much debris of the older rocks in mechanical suspension. Because, according to the manner in which water, when impregnated with such mineral elements, is separated from them by vaporization, and leaves the one class to deposit in stratiform masses, and the other to solidify into crystaline shapes, so is it found, by the geological development of the groups to which the attention has just been directed, that the results precisely coincide, and, likewise, with what was anticipated. The conclusion, therefore, is, that, as there has remained much material residium which the water *could not carry*

* First Impressions of England, pp. 177—185.

with it, by vaporization, but which it would assuredly *have swept* into the ocean had it been *drained* from off the surface of the land, the former must have been the method employed. *I shall assume, in consequence, that vaporization was the method of separation;* while it is, no doubt, confirmatory to myself, to be supported in this opinion by Prof. Playfair, who has so clearly applied the investigated facts of the case to elucidate the hypothesis of his friend Dr. Hutton; which, in the instance in question (although no allusion is made to the *source* of the heat acknowledged to have been indispensable for the production of the saline deposits), coincides in every other respect with the Dynamical Theory; while this latter can alone account for the other attendant circumstances so manifestly present—the evidence of previous solution—the suddenness of the desiccation—and the simultaneous character of the whole consolidating process.

To prevent any misconception, it should be clearly understood, that it was not *because there had been laws governing materialism established beforehand* that they were had recourse to at this, or at any other stage of the creation. All laws affecting materialism *were impressed upon it by the Creator himself* at the time and in the manner most conducive to the progressive development of a plan laid down before, and were thereafter rendered subservient to its further development. Indeed, it is in consequence of their having been then established, that we are constrained to recognise them now; and if success be desired in any undertaking, be content to employ them; and that we are, ourselves, unavoidably subjected to their influences.

That a clear and more abiding conception of this advertency may be formed, and the reader enabled more thoroughly to comprehend what may be brought forward in reference to it in the sequel, a vigorous endeavour must be made to conceive the earth to be in the condition in which it existed, while as yet it had no rotation around its axis; when shrouded in the atmosphereless deep as with a mantle; a stranger to the influences of light, it was comparatively more under the dominion of attraction. This is the condition in which he will have to consider *that it travelled for ages around the unillumined sun.* When at length the period arrived in which material LIGHT became essential for the development of the same progressive plan, and its elements having been prepared, the Light was introduced; when from thenceforward the earth and all materialism became subjected to the influence of a new and additional comprehensive law. The second universal *law* of matter—EXPANSION.*

* I have already clearly pointed out the source from whence I consider the expansive principle of the primeval world to have emanated, before the formation of the physical light, on the first day of the Mosaic week—"The Spirit of God moved on the face of the waters." I consider it opportune, however, to remind my readers, at this juncture, of what I have adduced on the subject, and to refer them again to the divinely revealed authority of Scripture, for the only elucidation which *can* be given.—AUTHOR.

The attractive and expansive principles were, from this period, placed on their present footing of antagonism. The introduction of the primary LIGHT, and its division from the darkness, caused rotation around an axis as its immediate effect; while this, in turn, gave rise to a transitory influence, of great power during the brief period of its existence—CENTRIFUGAL IMPETUS—one of the most important of the secondary agencies employed in transforming the earth, and also to another result of greater permanency, but of less ardent power—the alternation of day and night; one which, when estimating these attendant consequences in a meteorological point of view, must not, by any means, be overlooked.

Nor is it altogether sufficient to be able to estimate the *separate* effects of all those influences, or even their reciprocal effects upon each other. Attention must also be given to the results which emanated from the ORDER of their introduction into the material universe, and from the *precise* period when they were brought into operation. These two essential circumstances denote more clearly than any other, the SOURCE of these important and comprehensive laws: perhaps more so even than their amazing power and comprehensive extent—great as both of these are—inasmuch as they more evidently point out the exercise of infinite wisdom in the determination of the junctures when each should be brought into successive exercise.

Attraction was allowed first to wield its influential sway, until that which was wrought out under its shadowy covering, by the immediate exercise of Divine power, should be prepared for the reception of the expansive principle—LIGHT, which awakened the perfected materials from their uterine slumber, and by its concomitant power of centrifugal impetus placed them where they were destined eventually to be located.*

This exercise of mind will enable us not only more fully to realize the existence of an Omnipotent Power, and the exercise of an unlimited Will, but, likewise, to trace the profound wisdom of the choice of periods, when these other attributes should be made mani-

* Long after the foregoing was written, I observed the following passage in Mr. Whitehurst's work, which appears so confirmatory of the advantages of quiescence to the operations assumed to have been taking place during the non-rotatory period, that it is here transcribed:—"The component parts of the chaos," says that philosopher, "having thus arrived at a state of rest, with respect to the effects arising from gravity and centrifugal force, began more immediately to act according to their affinities, or the laws of elective attraction; for, according to the second proposition, particles of a similar nature attract each other more powerfully than those of contrary affinity, or equality. But, to illustrate this, let us suppose, that if a variety of salts were dissolved in one and the same menstruum, or mass of water, it will come to pass that particles of a similar nature will unite and form the same select substances as they were before solution; provided the menstruum remains perfectly quiescent. But, on the contrary, no union will take place among them, for the particles of the several salts will remain in a state of solution equally diffused throughout the whole mass of water; rest being so essentially necessary to the union of similar substances."—(Whitehurst's Theory, pp. 33, 34.)

fest by their results. And, at the same time, it will assist us to recognise the consequent modifications produced by each successive law on the combined influences of those which had preceded it; such, for example, as the effect of the alternation of evening and night, after the light of *morning* and of the day, upon the *heavens*, surcharged with watery vapour as they then were.

It will be conducive to the same preparedness of mind, to reflect on the *description* of *forces* which were then dominant over nature. They were all of a *direct* tendency. Attraction propended in straight lines from the periphery toward and through the centre. Expansion, on the contrary, from the centre towards the circumference. Centrifugal impetus, caused by rotation, partook of the character of expansion. That *lateral tendency* in the motion of matter which is apparently indifferent whether the direction be to the one side or to the other was not then known; and it was precisely when such lateral motion was absolutely essential; and when by the previous formation of the atmosphere, the region of least friction, it could be most effectually employed, that *clouds* appear to have been first "gathered together," or made to conglomerate, and on their vapory wings to collect the surplus water of the heavens into those deposits which had been prepared for them; when the Creator "brake up for them his decreed place, and set bars and doors upon them, and said, hitherto shalt thou come, but no farther; and here shall thy proud waves be stayed." A conclusion which will appear more proper still, if it be considered for a moment, that without the lateral movement of surcharged clouds, there could, humanly speaking, have been no fulfilment of the command. We have seen, *by the material residium of crystaline salts, and extensive deposits of mineral debris*, that the separation between the land and the water took place by means of vaporization, during which process the aqueous part would be caused to evaporate in straight lines from the surface of the heated earth; and unless, therefore, there had both been lateral motion, in various directions amongst the clouds, and that they had been charged with surplus watery vapour, there could have resulted *no "gathering together."* So long as the direct forces continued paramount, there might have been a dispersion like rays to or from a centre; but there could have been no result corresponding to *aggregation*. That such is really the case, a moment's reflection will convince every one. It can be imagined, that the watery vapour might, by the centrifugal impetus, or by expansion, have been impelled high into the atmosphere from the surface of the earth in parallel lines; and have been drawn down again towards the centre by that of attraction, or it may be conceived to have vaporized by the direct action of heat. But any motion corresponding to aggregation or free lateral movement, cannot possibly be considered to have arisen out of either the one or the other of these forces producing motion, nor even from any of their possible combi-

nations; while the probable consequences of the application of *direct* forces to the case in question, namely, *the separation of the water from the land without removing the material residium,* could not have been effected, or even assisted in the slightest degree, by the consequent operation which would have ensued by the mere raising of the water and letting it descend again *on the same surface.* Nothing but the formation of clouds, and their easy and rapid movement, by means of the atmosphere, could have wrought out the design then intended. Without motion there could have been no "gathering together," and having shown that neither of the direct motions then known, nor any combination of them could have produced this effect, the only conclusion which remains is, *that a motion of aggregation was then introduced into the material universe,* and that this was effected by means of electricity or light.

This assumption is confirmed by the dicta of meteorologists, as shown by the following opinions which they have expressed on the subject, namely:—

"It is evident," says Mr. Hutchinson, "upon reviewing the subject,"—the formation of clouds—"that, with the exception of some of the circumstances enumerated under the first cause of the existence of clouds, Wind is a necessary agent in their formation. If there were no such thing as wind, which would be the case if the air was not liable to expansion by means of heat, no clouds, with the exception of mists and fogs could ever make their appearance. All the moisture evaporated in such circumstances during day, would be returned to the earth in the form of dews, or falling mists, during night. In general, then, it may be remarked, that whatever effect a wind of moderate velocity is calculated to produce upon the hygrometric condition of the atmosphere, will be increased by every increment in its velocity, and diminished by every decrement."

Again—

"The circumstance of clouds gathering together in heaps, so as to form the several descriptions of cloud, proves that, though the vesicles of which they are composed be mutually repellent within a certain distance, they are mutually attractive beyond that distance. If the vesicles were mutually repellent at all distances, instead of congregating together into those masses which we call clouds, they would separate as far as possible from each other, and diffuse themselves equally throughout the atmosphere."*

"The proximate cause of the formation of clouds," says Dr. Thomson, "is the loss of caloric in the humid atmosphere, and condensation of the moisture; but we are still ignorant of the ultimate cause of the phenomenon."

And after alluding to several explanations which have been attempted, he continues—

"A far more plausible theory than the first attributes it to currents, upwards and horizontal (Gay Lussac). Another hypothesis (Luke Howard), assigns it entirely to electrical agency. We know that electricity has much

* Principles of Meteorology, pp. 102, 103, 167.

to do with the phenomenon; it is largely developed during evaporation, as was long ago shown by Volta, Saussure, Lavoisier, Laplace, and Bennet, while the vapour acquires that kind denominated *positive*, the water which remains being *negatively* charged. . . . . . Why certain clouds should be positively and others negatively charged, is not yet determined, though the fact is incontestable. Mr. Luke Howard has proved that the electricity of the nimbus cloud is positive internally, and negative at the circumference;"* and so forth.

It is very essential to bear in mind, that one of the immediate consequences of *direct* forces, would be to saturate the atmosphere with equal proportions of watery vapour for all given zones of latitude; the action and reaction of the direct forces on matter being equalized all over the earth's surface, in accordance with the static condition of equilibrium of a sphere in rotation; that is, all portions of the atmosphere would become equally charged with watery vapour in proportion to what they could respectively receive. There would, indeed there could have been no unequal loading of any part of it with aqueous exhalations, for there existed no force which could propel matter out of direct lines, or of oblique lines *parallel* to each other; this advertency is quite irrespective of the immediately subsequent action of the heated and elevated continental ridges, and we must therefore endeavour to learn, from the testimony of scientific writers, whose announcements support the *ninety-fourth* Theorem, some of the more recondite but well established and comprehensive principles, whose combinations of action and reaction on each other, seem to govern and to give effect, by currents of wind, to the various meteorological vicissitudes, namely, "*The existence of a constituent temperature for the maintenance of water in a state of vapour. The opposite tendencies, of* AIR *from the colder to the warmer parts; and of* VAPOUR *from the warmer to the colder parts of the atmosphere and terraqueous surface. The different rates at which the temperature and tension of air and of vapour decrease as they ascend from the surface of the land or sea. The different capacities for heat of these two component parts of the earth's surface. And, lastly, the unequal distribution of the electric fluid in the nephalic masses of the atmosphere, and its tendency to a state of equilibrium, seem to be the most obvious principles, whose combination and mutual action on each other govern and modify the meteorological state of the atmosphere.*"

"We can suppose the earth," observes Prof. Whewell, "with no atmosphere except the vapour which arises from its watery parts; and if we suppose also the equatorial parts of the globe to be hot, and the polar regions cold, we may easily see what would be the consequence. The waters at the equator and near the equator, would produce steam of greater elasticity, rarety, and temperature than that which occupies the regions further polewards; and such steam, as it came in contact with the colder vapour of the higher latitudes, would be precipitated into the form of water. Hence

* Introduction to Meteorology, pp. 123, 124.

there would be a perpetual current of steam from the equatorial parts towards each pole, which would be condensed, would fall to the surface, and flow back to the equator in the form of fluid. We should have a circulation which might be regarded as a species of regulated distillation. . . . . .

"If we had the earth quite dry, and covered with an atmosphere of dry air, we can trace in a great measure what would be the results, supposing still the equatorial zone to be hot, and the temperature of the surface to decrease perpetually as we advance into higher latitudes. The air at the equator would be rarefied by the heat, and would be perpetually displaced below by the denser portions which belonged to colder latitudes. We should have a current of air from the equator to the poles in the higher regions of the atmosphere, and at the surface a returning current setting towards the equator, to fill up the void so created. . . . . . The effect of a heated surface of land would be the same as that of the heated zone of the equator, and would attract to it a sea breeze during the day time, a phenomenon, we also know, of perpetual occurrence.

"Thus, in the lower part of the atmosphere, there are tendencies to a current of air in one direction, and a current of vapour in the opposite; and these tendencies exist in the average weather of places situated at a moderate distance from the equator. The air tends from the colder to the warmer parts, the vapour from the warmer to the colder.

"The various distribution of land and sea, and many other causes, make these currents far from simple. But, in general, the air current predominates, and keeps the skies clear, and the moisture dissolved. Occasional and irregular occurrences disturb this predominance; the moisture is then precipitated, the skies are clouded, and the clouds may descend in copious rains.

"These alternations of fair weather and showers appear to be much more favourable to vegetable and animal life than any uniform course of weather could have been. *To produce this variety we have two antagonist forces, by the struggle of which such changes occur. Steam and air, two transparent and elastic fluids, expansible by heat, are in many respects and properties very like each other; yet, the same heat similarly applied to the globe, produces at the surface currents of these fluids tending in opposite directions.* And these currents mix and balance, conspire and interfere, so that our trees and fields have alternately water and sunshine; our fruits and grain are successively developed and matured. Why should such laws of heat and elastic fluids so obtain and be so combined? Is it not in order that they may be fit for such offices? There is here an arrangement which no chance could have produced. The details of this apparatus may be beyond our power of tracing; its springs may be out of our sight. Such circumstances do not make it the less a curious and bountiful contrivance; they need not prevent our recognising the skill and benevolence which we *can* discover."*

"Variations of temperature on different parts of the earth's surface," says Mr. Hutchinson, "disturb the atmospheric equilibrium, and give rise to aerial currents; while on the other hand, aerial currents, according as their direction is from a cold or a warm climate, produce important alterations in the temperature of the incumbent atmosphere. Again, variations in the atmospheric temperature are principally instrumental in the formation and dissolution of clouds; while the existence of these reduces the temperature

* Bridgewater Treatise, pp. 96—101.

of the subjacent atmosphere during day and summer; and augments during night and winter, and unitedly produce the varied machinery of the weather. . . . . .

"Winds, in every case, whether at the level of the sea, or at any elevation above it, originate in simultaneous inequalities of atmospheric density, or simultaneous inequalities of incumbent atmospheric pressure at corresponding levels, in different places. And, according to the principle of fluids in their motions, obeying the preponderance of pressure, the direction of the wind must always be from where the incumbent pressure is greater to where it is less. . . . . .

"Whatever, therefore, produces a simultaneous difference of temperature in different portions of the atmosphere, at equal altitudes above the level of the sea, necessarily gives rise to qualities of barometrical pressure, and thus remotely becomes the cause of wind.

"Agreeably to the preceding observations, the most general cause of wind is the gradual diminution of the mean annual temperature from the equator towards the poles; and the prevailing direction in which the upper part of the atmosphere moves is from the warm towards the colder climates, viz., from the equatorial towards the polar regions. And, on the contrary, the prevailing direction in which the lower half of the atmosphere moves, is from the cold to the warmer climate; and accordingly from the polar towards the equatorial regions."*

The recent work of Dr. Thomson affords the following corroboration:—

"When by any cause the atmospheric molecules are disturbed, the motion communicated to the air is denominated wind: it arises as a consequence of changes in the density of the atmosphere. Like water seeking its own level, the particles of air rush to supply the partial void, with a velocity and impetuosity proportioned to the existing cause; so in the higher regions, those particles which, expanded by heat, have ascended by reason of their diminished gravity, flow out according to a similar law, and thus two currents are established, one on the surface of the earth, and the other considerably above, moving in opposite directions."†

"It will be recollected," observes Mr. Reid," "that there are two great powers acting upon every kind of matter, *attraction* and *repulsion*. This latter principle is generally believed to be the same as *heat*. If *cohesion* were the sole ruling power, the world would be a dull, inert mass, for the tendency of cohesion is to draw the particles of bodies into close contact with each other, and to preserve them in that state. But the repulsive principle, by driving asunder the particles of bodies, infuses life and activity into inanimate objects.

"To illustrate this, it will be sufficient to mention, that without the power of heat or repulsion, there could be no winds, rain, dew, rivers, streams, or springs."‡

With these expositions, on this abstruse subject, the complex and seemingly capricious machinery of the weather, this chapter will conclude, that we may enjoy a slight respite, and have time to meditate

* Hutchinson's Principles of Meteorology, Introduction, pp. 269, 131, 272.
† Introduction to Meteorology, p. 377.
‡ Popular Treatise on Chemistry, p. 22.

on what has been perused, before proceeding to its application in conformation of the Dynamical Theory; and ere it is attempted to be shown by what means these meteorological phenomena, and the formation of the atmosphere, at this particular juncture, can be made available, to convince the reader, *that there was a long but indefinite period, during which the earth had no rotation around its axis.*

SECTION VII.

COMPLETION OF THE ATMOSPHERE; SEPARATION OF THE SEA FROM THE LAND; AND THEIR IMMEDIATE COMBINED RESULTS.

CHAPTER XXXIV.

Preliminary observations. Different consequences which result from the application of the Expansive principle to the Aerial and to the Aqueous bodies of the atmosphere exemplified by what took place at the epoch alluded to. Evidence that it was at this juncture the Atmosphere was completed, and the Sea and the Land were separated from each other. Concurring testimony that these events were effected by Vaporization. Scientific evidences as to the action and reaction of these great natural bodies on each other, and their beneficent results. A corroborative line of proof adopted and made good by the character and capabilities of the Phanogamous division of plants; and the opportune period recorded as that of their formation.

The immediate results of the first rotation of the earth around its axis would be to elevate continental ridges, intensely heated; to depress oceanic hollows of corresponding magnitude; to carry upwards, by means of the former, immense longitudinal waves, the latter retreating, and carrying down, to a certain extent, masses of water, corresponding to the spaces upon which they rested; while the upper strata of water would be dispersed in extreme tenuity, by the general rotatory impulse, augmented in the zones above the continents by the incandescent mountain chains thrust into their midst. Before this period, it must be reiterated, there existed no motion, except in straight lines, either to or from the centre, or diagonal thereto as a compound of those primary directions, but none which could cause particles of inert matter to move out of parallelism; while there now exists, as shown by the theorem and evidences last appealed to, a law in nature, whereby the aerial portion of the atmosphere propends from the colder to the hotter regions; and the vaporous constituents from the hotter to the colder places, without reference to direction, beyond what is impressed upon them by these irresistible impulses. And another constitutional law, by which its aqueous associate is induced to form itself into vaporous vesicles, of wonderful tenuity, possessing dif-

fusive principles within and immediately around themselves, yet with general attractive affinities by which they congregate or gather together into those gorgeous but fantastic forms which visible vapour or clouds assume; and having been made aware of these several conditions, and of the existing phenomena connected with the comprehensive machinery of the weather, application may be made of them to the subject more immediately under consideration.

Alluding again to the normal law of materialism, "that inert matter can neither generate, alter, nor overcome motion in itself"—and being without the knowledge of the existence, up to the period alluded to, of any source of motion save in direct lines, while the insufficiency and inappropriateness of this description of motion is freely admitted, to effect the separation of the water *from the earthy and the saline residium, which exists to this day as an incontestable proof of the separation which actually took place;* the argument is reduced to one of those unavoidable dilemmas into which reliance alone on the laws of materialism would infallibly lead. *Motion*, impelling matter in *parallel* lines, could never have effected what we are constrained to admit has been done. And it is precisely when thus critically circumstanced, when we cannot take one step forward of ourselves, that the opportune interference of the Creator relieves us from the difficulty: "Let the waters *be gathered together*, and let the dry *land* appear."

From what has been said, therefore, it will not be difficult to imagine the land to have been entirely enveloped by watery vapour, which, by reason of the causes then in combined operation, especially of the diffusion principle, had risen up, and, for a limited period, was sustained by the newly-formed atmosphere, in which, as there had yet been no lateral motion, the mass of encircling vapour remained unbroken and undispelled; and that, had there existed a human eye, that eye, however space-penetrating, could not have distinguished the continental ridges; to it the land would not, as yet, have appeared.

It may be well to remember also, that the impelling power, which the Deity chose to wield while thus putting forth those manifestations of creative energy, was the *expansive principle of light in its primary condition.*

And, bearing these few important circumstances in mind, it is only necessary to recur to what has been made so clear, by the announcements of philosophy, when declaratory of the meteorological phenomena, to feel convinced "*That the application of the same heat, looked upon as a synonyme of the principle of light or electricity, applied to the globe, and acting upon the two principal constituents of the atmosphere—Aqueous Vapour and Air—would produce currents of these fluids tending in opposite directions: the air tending from the colder to the warmer parts; the vapour from the warmer to the colder.*"* While

* Theorem 94 and evidences.

the effect of this double and contrary result of the same propelling power, as shown by the preceding quotation from the works of Professor Whewell and other meteorologists, is so apposite, that it makes it to be understood thoroughly and for ever, how the impartation of the primary light, and of the intense heats from the continental ridges, at the period referred to, was the only agency which could have occasioned an almost instantaneous dispersion of the watery vapour from off the warmer regions, over the continents, by transference to the colder zones above the oceanic depressions, where, losing the latent heat which retained the aqueous portion in a vaporous state, it would be discharged in copious rain, and thereby fulfil the Creator's command—"Let the waters be gathered together into one place, and let the dry *land* appear." There is so much sublimity in the simplicity of this announcement: so much of omnipotence combined with omniscience; a handling of the vast materials of the universe with so much ease; and the constraining of potent and comprehensive powers to fulfil a definite purpose, that it is scarcely possible to peruse this portion of Scripture, and view it as now done, without confessing, that it is the announcement of the Spirit of HIM who alone could deal with those elements, and cause them to produce those monuments of His power which appear everywhere in creation. This will also enable us to understand, that it is solely as the permanent consequences of the command then given, *that watery vapour still propends from the hotter to the colder regions, in opposition to its atmospheric associate,* the *aerial* part; that they are, in fact, differently acted upon by electricity, and not from any inherent principle which resided in them.

The reasons so strongly urged in favour of the position assumed, namely, *that the waters were separated from the land by vaporization,* are all borne out and confirmed by what has just been stated. There existed powerful and influential motives for vaporization having rapidly, extensively, and effectually taken place all over those parts of the earth's surface, which now constitute its terraine portion. It was essential, for the completion and adaptation of those portions for the world's future occupants, that the various mineral salts, soils, and sand should not be swept away, when the water with which they were combined was separated from them, but that the aqueous portion should be insensibly and almost invisibly evaporated from the salts and soils; and that these should assume their dry and crystaline state, to remain as blessings to entire races of beings destined long afterwards to employ them for their respective purposes. And thus the sub-aqueous heat, arising from the fused mountain chains, was simultaneously applied beneath, to occasion rapid evaporation; whilst the expansive principle of light was caused to impinge tangentially upon these vaporous exhalations, in a direction external to the surface, and thereby to complete their entire separation. In short, no conceivable combination of circum-

stances could have been more complete or more favourable for the accomplishment of the object then designed, as far as regards the terraine part of the world's surface.

No such end being desired with respect to the depressed portions of the earth's surface, destined to receive the waters of the ocean, the same over-ruling wisdom, which applied heat to the elevations, arranged that these should be less capable of producing evaporation; and by this opposite tendency they were caused to forward the work of creation almost as directly as the evaporizing process over the land. It is not meant by this to assert, that there was absolutely *no* friction, and consequently *no* heat occasioned by the depression of the oceanic hollows of the world. It is believed these effects resulted from *depression* as well as from *elevation;* but owing to the description of force employed, centrifugal impetus, it is considered, that the *elevatory* movement beyond the original contour of the non-rotatory sphere, far exceeded the *depression within* that original outline; while, at the same time, the oceanic cavities would be covered by comparatively a much greater depth of water than the uprising continents, and be subjected to the application of altogether different degrees of heat and other evaporizing influences. Indeed, it cannot be supposed consistent with the wisdom of the Creator to have occasioned the vaporization of any moisture unnecessarily, when it was His design "to gather the waters together" into "one place," and that place, as we are afterwards informed, was the "sea."

On contemplating, for a moment, the conclusion just come to, it must appear to be immediately dependent upon the *first rotation of the earth around its axis;* the centrifugal impetus, engendered by this event, constituting, as a secondary cause, so essential an element in the formation of those portions of the Creator's work which we have been considering, that it is altogether impossible to imagine their existence—as it has pleased Him to form them—independently of that special force. The deduction from this, as to the *period when* the waters were separated from the land, is so obvious, as scarcely to require any further notice. It could only have been at the particular juncture, when the earth was first put into rotatory motion, that the centrifugal impetus necessary, as the element and the description of power required, could have been produced; and it is precisely at that particular period when, we are told, "the waters were separated from the *land.*"

When, in connexion with this striking coincidence, the attendant circumstances of the creation are made to pass in brief review, we become thoroughly convinced of the perfect adaptation of the means to the end designed; as well as of the power and wisdom which were displayed in constraining the successive parts of the work to contribute towards the completion of that which was to follow. This feature, so characteristic of the wisest forethought, has more than

once been already pointed out; but in no stage of the creation does it manifest itself more conspicuously than at the period now referred to.

The increased pressure, occasioned by the completion of the atmosphere, would directly contribute to the condensation of aqueous vapour; while the downward tendency of the surcharged clouds, from the higher and more heated regions, above the continental land, towards the lower and colder spaces occupied by the oceans, the natural direction of all bodies under the influence of gravitation, and more especially of the nephalic masses, when the equanimity of barometrical pressure is interfered with, would accelerate their descent, and render condensation and their discharge into the general reservoir of the sea more speedy and copious; a consummation which would, to a considerable degree, be facilitated in succession all around the globe as the comparative warmth of the "morning" gave place to the darker and colder vicissitudes of "evening."

The following extracts, though written for a different purpose, bear so directly on this part of the subject, that no apology is made for inserting them:—

"The phenomena are as follow," says Mr. Whitehurst, in his Theory of the Earth:—"In the middle or hottest part of the *Day*, the sea breeze blows towards the land, in every possible direction; and in the middle or coldest part of the *Night*, the land breeze blows towards the sea, in every possible direction. Thus they alternately succeed each other, as constantly as night and day. These singular phenomena seem to arise from the following unalterable laws of nature, namely: those properties of the air whereby it becomes subject to rarefaction by heat and condensation by cold; and in part to the situation of the islands within the torrid zone, where days and nights are nearly equal all times of the year.

"To the above we may add, that water is a conductor of heat or cold; and that the earth is a much inferior conducting substance.

"Hence the surface of land under the torrid zone, acquires much more heat than the surface of the sea: consequently the atmosphere of the former becomes more rarefied than that of the latter, and rendered thereby specifically lighter than the air at sea. The equilibrium of pressure being thus destroyed, the air upon the island ascends by the superior weight of the air at sea, which moves in all directions towards the central parts of the island, and thus produces a sea breeze. When night approaches, the sun's heat abates, until the atmosphere at land becomes equally dense with that at sea. The equilibrium of pressure being thus restored, the sea breeze totally ceases and remains quiescent; till cold, increasing by the absence of the sun, accumulates on the surface of the islands, and condenses their incumbent atmospheres more than that at sea. The land atmosphere being thus rendered specifically heavier than the air at sea, begins to descend by its superior weight, and then blows in all directions towards the sea; till the sun returns and restores the two atmospheres to an equal density; the air then becomes stagnant, and remains in a quiescent state, till it is again rarefied by the accumulation of heat, as before."*

* Whitehurst's Theory of the Earth, 1786, pp. 148—150, a work seldomer referred to than perhaps it ought to be.

"In all maritime or insular situations in warm climates," observes another writer, "where the sun is nearly vertical, and where, accordingly, it exerts a strong heating influence, the surface of the land becomes warmer during day, and by more rapid radiation, colder during night, than that of the ocean. The result is, that the atmosphere over the land, from participating in its excess of warmth during the day, is expanded upwards, and gives rise to a current in the upper portions of the atmosphere from the land towards the sea; and this, in its turn, in accordance with the principles already explained, gives rise to a current at the surface of the earth, from the sea towards the land. . . . . . Sea and land breezes, as above explained, afford the best practical illustration of the causes which produce winds when their direction is regular, and of the principles which regulate their direction and velocity."*

Dr. Thomson confirms this when he says—

"The *sea and land breezes* are diurnal winds; they are best studied in tropical climes, for there the exciting cause acts with greatest power. They are altogether due to solar influence; the land being heated by day more than the sea, the air above the former is more highly rarefied than that over the latter, hence a current from the sea, or a sea-breeze, is established; at night the reverse is the case, for by terrestrial radiation the ground becomes colder than water, and a land-wind blows to preserve the equilibrium of the atmospheric forces."†

Besides the more immediate effect of gathering the waters together, and separating them from the *land*, towards which all those contemporaneous secondary causes were made to contribute, there were other events being brought about during their mutual action on each other, which were, likewise, as essential to the well-being of those races, endowed with voluntary motion, which were so soon to become the occupants of the gorgeous pedestal then preparing for their reception; and it may be well to bear in mind that up to this period, and for a day and night thereafter, there was not, in the whole world, a creature possessing the faculty of full and free locomotion. Therefore, whenever there is occasion to reason concerning motion up to this time, the idea must be restricted to those descriptions which proceed from attraction, repulsion, or from dynamical causes.

The more recent discoveries of science, at every moment and in every branch of research, present us with continual proofs of the manifold wisdom which pervaded the operations of the Creator—the arch-chemist of nature. That which the assiduity of chemists has lately enabled them to make out, with respect to the composition of earths, affords a striking example, alike of the wise forethought and of the providential care which characterizes the production of the original earthy and mineral substances of the world, and also of the fitness of the juncture, on account of the abundance of the elementary constituents then present, when these earthy mate-

* Hutchinson's Principles of Meteorology, p. 287.
† Introduction to Meteorology, p. 385.

rials were formed. But let chemistry itself bear testimony to the correctness of these observations.

Professor Donovan says:—

"Rocks, stones, and earths appear dissimilar to each other, yet observation shows, that the nature of all of them is the same. Stones and rocks are often found mouldering into earth, and earth is known to harden into stone. The process of mouldering produces no change further than breaking down the cohesion of the rock; accordingly, we find the soil at the foot of rocky mountains to contain the same ingredients as the rocks themselves. . . . . . Now, as these rocks, when broken down into small particles or powder, constitute earth, chemists have denominated the ingredients of which rocks and stones are composed, *earths;* and these are, consequently, of different kinds."

After describing minutely the composition of the precious stones, and explaining the nature of their chief components, *alumina, silica, glucina, zirconia,* and *yttria,* he goes on to state:—

"We shall take leave of the gems, and proceed to consider the nature of a much less costly class of minerals, although, in point of utility, some of them are of far greater importance. . . . . .

"Marbles, for instance, notwithstanding their value, are the same substance with common limestone and chalk, with a slight difference only in purity. Limestone is one of the most abundant minerals in nature; it sometimes constitutes the substance of whole mountains. . . . . . When water is poured on burned limestone it is immediately absorbed, and the lime appears as dry as ever. In a short time, however, it swells, bursts, grows hot, discharges steam, and falls to powder. The same phenomena are exhibited by marble and chalk, after burning, if similarly treated.

"There are two minerals very different from limestone or marble, and from each other, which, however, agree with limestone in the property of affording *earths,* that when water is poured on them suddenly become hot, and undergo the process of slaking. These minerals are named *carbonate of baryta,* and *carbonate of strontia,* and the *earths* obtained from them are called *baryta* and *strontia.*"*

"The preceding earths are all which the ingenuity of chemists has been able to discover; and of these are composed all the gems, stones, rocks, mountains, and soils that are found throughout and constituting the globe. From this examination we learn, that the solid parts of the globe, as far, at least, as human industry has discovered, are composed of a few earths and metals, each being presented under an astonishing variety of forms. And it will presently be shown, that the distinction between earths and metals, evident as it may appear, is not well founded, ... for of late years it has actually been demonstrated that earths are, themselves, metallic oxides. This has been shown by extracting oxygen from them; and determining that in each case, globules of a peculiar metal made their appearance. To metallize the earths, it is only necessary to subvert the affinity subsisting between the metallic basis and the oxygen, by means of some

* It should be observed, that during the period when these earths and soils were composed, the newly-formed atmosphere was in a peculiar condition; and it will be for us to consider how far these several carbonates of lime, of baryta, and strontia, would be modified in their results by being fused and slaked in that state.—AUTHOR.

body having either a naturally stronger affinity for oxygen than the basis, or made to have it by art. The oxygen being withdrawn from the compound, the basis will make its appearance in the metallic state. What these means are it is not necessary here to detail; it is sufficient to say, that it was chiefly through the application of the powerful agent called *galvanism* that the difficulty was overcome; but the medium of natural affinities was sometimes sufficient. When any of these earthy metals was presented, at an elevated temperature, to the action of oxygen, the latter was absorbed, and the original earth was reproduced. The metals obtained from the earths are named aluminum, glucinum, yttrium, barium, calcium, strontium, magnesium, to which list a new metal, thorium, has lately been added.

"It appears, therefore, from the investigations of modern chemists, that the globe of the earth is one vast mass of metals of different kinds, disguised by various substances, but chiefly by oxygen."*

These extracts demonstrate, in a concise but perspicuous manner, the intimate connexion which exists between earths, metallic oxides, and metals; while they trace them all back to "the great globe itself," and to the slow, progressive, but powerful agency of galvanic currents. By this, not only a clear glimpse is obtained of the way in which these mineral substances were formed at first, in the womb of nature; but, likewise, of the reasons which led to the thrusting up of heated continental ridges and mountain chains, composed of these metallic substances, into the midst of a world of waters plentifully saturated with saline and oxygenous elements: whereby the prompt and abundant formation of loose earths and soils, suited for the forthcoming vegetable kingdom, took place, at the precise juncture when they were required; when they could no longer have been dispensed with, and while their earlier formation (had such been possible in the then condition of the creation) would have deprived them of much of that efficacy, which, as newly-formed earth and soils they essentially possessed.

Nor have we yet exhausted the resources which science possesses to make manifest the wisdom and providence of the Creator, especially that peculiar feature of these attributes, which shows that from one and the same general combination of elements, several concomitant effects are made to spring.

This is more than usually manifest on the present occasion; for we shall be made aware, by evidences deduced from scientific sources, distinct from those which have been quoted, that by employing *water*, after the *atmosphere* had been formed over it, as the medium wherein the chemical combinations were conducted which produced the loose earths and soils, and also by applying the heated masses underneath the water, the *refrigeration* of the heated continents and their mountain ranges was greatly accelerated; and that while the caloric which they radiated in such profusion was acting with so much effect on the elements of water and air, and the asso-

* Chemistry, in Cab. Cyc. pp. 115—120.

ciated ingredients of the former, these were reacting, as refrigerators, with as much greater an influence than would have been produced by the ethereal medium or by vacuo, as their densities exceed that of these media respectively.

"Heat," observes Mrs. Somerville, "applied to the surface of a fluid is propagated *downwards* very slowly, the warmer, and consequently the lighter strata always remaining at the top. . . . . . When heat is applied *below* a liquid, the particles continually rise as they become specifically lighter, in consequence of the caloric, and diffuse it through the mass, their place being perpetually supplied by those which are more dense. The power of conducting heat varies materially in different liquids. Mercury conducts twice as fast as an equal bulk of water. A hot body diffuses its caloric in the air by a double process; the air in contact with it being heated, and becoming lighter, ascends and scatters its caloric; while, at the same time, another portion is discharged in straight lines by the radiating powers of the surface. . . . . . Hence a substance cools more rapidly in air than in vacuo, because in the latter case the process is carried on by radiation alone. It is probable that the earth, having originally been of very high temperature, has become cooler by radiation only. The ethereal medium must be too rare to carry off much caloric."*

"The constituent particles of solid bodies," we are informed by the article on Heat in the Cabinet Cyclopedia, "being incapable of changing their mutual position and arrangement, the heat can only pass through them from particle to particle by a slow process; but when the particles forming any stratum of a liquid are heated, their mass expanding becomes lighter, bulk for bulk, than the stratum immediately above it, ascends, and allowing the superior strata to descend, ... a constant series of currents upwards and downwards is thus established, and the heat is diffused by the motion of the particles among each other. . . . . .

"If, however, heat be applied to the highest stratum of the liquid, this effect cannot ensue. In fact, the heat is, in this case, *conducted through* the liquid. Liquids are, in this manner, observed to have extremely low conducting powers: for a long period they were supposed to be altogether incapable of conducting heat. . . . . .

"The process of cooling which a hot body undergoes when suspended in air is chiefly owing to the radiation of heat from its surface; but another cause of the diminution of heat conspires with this. The particles of air in contact with the surface of the body receive heat from it, and thus becoming specifically lighter, ascend and give place to others. Thus heat is imparted constantly to fresh portions of the air, and carried off by them. If a hot body be suspended in a liquid, the process of its cooling is altogether produced by this means, for in that case no radiation takes place, as in the instance of refrigeration in air."†

These concise but apposite passages show not only that the cooling of the heated continents would be accelerated by the aerial elements then present, but likewise that the oxydation of their metallic and metalloid components would, at the same time, be greatly facilitated by these having been introduced while in this condition, or rather

* Connexion of the Sciences, pp. 246, 247.

† Heat, in Cab. Cyc. pp. 335, 336.

thrust up while in this state, into the midst of water abundantly saturated with free oxygen. The sudden and violent evaporation, from off the continents, of the water raised into steam by the intense heat of these intrusions, would occasion at the same time a rarefaction in the aerial portion of the atmosphere, which would cause an almost irresistible rush of wind, underneath, from the colder regions of the ocean towards and over the warmer lands; and, by this action, assist in producing the effect next designed to be wrought out, namely, to reduce the temperature of the terraine portion; and the more so, as these colder streams of air were confined to the lower regions of the atmosphere, and would on that account accelerate oxydation, and prepare the oxydized mineral material, so necessary a component of the soil which was so soon to be clothed with the vast variety and extent of those interesting objects, constituting the vegetable kingdom of the present day.

The effects of currents of air, both in a meteorological and a chemical point of view, are so influential in producing the combined results to which allusion is now made, that, except for the information of those who may not have given sufficient attention to the subject, evidences need not have been brought forward. The following brief quotations, from distinct sources of scientific research, will, however, tend to illustrate the consequences which would flow from the alternations of colder and hotter currents:—

"There is a constant evaporation," observes Mrs. Somerville, "from the land and water all over the earth. . . . . . In calm weather, vapour accumulates in the stratum of air immediately above the evaporating surface, and retards the formation of more; whereas a strong wind accelerates the process, by carrying off the vapour as soon as it rises, and by making way for a succeeding portion of dry air."*

"If air does not dissolve water," asks Mr. Donovan, "or exert any affinity on it, as is supposed by the hypothesis of Dalton, how does it happen that the evaporation of water is greatly promoted by passing a current of air over its surface? . . . . . I am inclined to think," he observes a little further on, "that the agency of both heat and affinity is necessary to the explanation of the phenomena. The increased solubility of air in water, in proportion as the latter is warmer, may be explained by the intensity of affinity; for heat is known, in many cases to exalt its force."†

And writers on meteorology give the following concurring testimonies, as far as they are called upon to observe and record these vicissitudes:—

"When the wind blows from a cold towards a warmer climate," says Mr. Hutchinson, "the air, by communicating with a progressive warmer surface, has its temperature and capacity for aqueous vapour more rapidly increased than when it is supplied with humidity by evaporation. . . . . The

* Connexion of the Sciences, p. 250.

† Chemistry, in Cab. Cyc. p. 150. In reference to this observation, it should be remarked, that in the case in question, the heated condition of the water would augment the degree of affinity.

piercing and refrigerating influence, commonly ascribed to north and north-east winds in this island, is owing, not so much to their absolute thermometric coldness, as to their undersaturated state of dryness, and their consequently increased effort in abstracting heat from the human body, and from all other moist surfaces, by accelerating evaporation.

"When the wind, on the contrary, blows from a warm towards a colder latitude, and has its temperature slowly reduced by communicating with a progressively colder surface underneath, its capacity for aqueous vapour is simultaneously diminished.

"That the upper half of the atmosphere moves in the opposite direction to the lower, in the case of sea and land breezes, monsoons, and generally when the prevailing direction of the wind in the lower half of the atmosphere is from a cold towards a warm climate, can hardly be doubted.

"The atmosphere in a warm climate, by being expanded upwards, in consequence of the superior temperature, to a greater elevation than that in the colder climate, generates a current in the upper half of the atmosphere from the former towards the latter. . . . . . This supplies air to the atmospheric columns over the colder districts, and increases the atmospheric pressure. Hence a counter current in the lower half of the atmosphere, from the cold towards the warm climate, is generated and maintained."*

"A current or high wind," says Dr. Thomson, "by disturbing the equilibrium of the molecules of the air, promotes evaporation."†

The wisdom which ordained that these events should take place *when* they did, is, likewise, most remarkable. Had those violent and irresistible changes of temperature, or, in other words, the sudden rush of the wind from the sea towards and upon the land, taken place *after* it was clothed with vegetation, the whole must inevitably have been rooted up, torn to pieces, and destroyed; while, at the same time, their existence, as a matted covering over the terraine surface, would have materially impeded the thorough evaporation of the water from off the land. These evils, however, were alike avoided by the Creator having completed *beforehand* the three constituent elements which unitedly contribute to the equable and healthfully moderate variations of climate which the world now enjoys—*the* ATMOSPHERE, *the* LAND, *and the* SEA. And we find that it was precisely at this opportune juncture that these three great natural systems or bodies were completed.

With reference to the allusion which has just been made to the combined agency of the Atmosphere, the Land, and the Sea, as being conjointly essential to produce the delightful and wholesome vicissitudes of weather, so necessary for the well-being of the animated and the vegetable existences with which the surface of the globe is covered, another gratifying evidence of the surpassing wisdom of the Creator will be enjoyed when further investigation is made into the manner in which the separation between the *water* and the *land* was effected, and contemplate it with reference to the case in question. It will be recognised in the fact of *vaporization and trans-*

* Principles of Meteorology, pp. 23, 94.

† Meteorology, p. 104.

ference, by means of the atmosphere, having been employed, that the Being who ordered it, possessed complete power over all; the world being but as a ball in his hands, with which he did whatever seemed to him to be good.

It was formerly shown at great length, and with considerable care, that the *water,* after having been purified, by undergoing a process of deposition which continued through the whole period of non-rotation, had, towards the close of that stage of the earth's existence, reached such a state of equilibrium, with respect to the saline and earthy ingredients which it held in chemical suspension, that no further deposition would have taken place; but in that condition it might have remained *ad infinitum,* had it not pleased the Creator to introduce the new principle of light, and, thereby, to impress rotatory motion upon the immense sphere over which the water was spread as a liquid envelope: and by means of the centrifugal impetus to break up the outer crust of the earth into continental ridges, insular elevations, and oceanic depressions. And, by the same and other forces, to expel from the primeval water those free gaseous exhalations which formed the major part of the atmosphere. Whereby the earth, in place of being a concentric rock-bound surface universally covered by a liquid hollow sphere of equal depth, was transformed into the diversified and gorgeous world it now is, with its feracious lands, its sparkling, limpid seas, and, over all, its glorious azure canopy, each contributing to the perfection of the other; and, together, to the well-being of its numerous inhabitants.

Considerable pains were likewise taken, to show, that the atmosphere is continually operating upon the ocean in such a manner as to separate the pure water from its saline, acidulous, and earthy ingredients, over the whole surface of its almost illimitable extent; and, by means of certain meteorological phenomena, of which *wind* and *clouds* are very important essentials, to furnish the terraine portion of the earth's surface, with the requisite supply of moisture and fresh water. The vicissitudes of weather, which, in fact, are the verifications of those essential operations in nature, are so well known and so frequently observed by all, that further explanation of them is quite unnecessary.

But it may not so obviously occur to every one, that had the separation between the *land* and the *water been effected by* DRAINING, *or by any other means than by* VAPORIZATION, *those necessary and salubrious interchanges between the water of the ocean and the land, by means of their connecting syphon, the atmosphere, would not have taken place with the same beneficial results.* This will be shown by recurring to the fact of the primeval water having been purified to a condition of static equilibrium, which was designed to be maintained as the constitution of the present seas.* And inferring therefrom, that

* By the *ninety-first* Theorem and evidences it will be seen, that wherever an exact

had that portion of the primeval water which covered the continental ridges and other terraine elevations, been gathered *in its original condition*, into the great reservoir of the ocean, that is, in combination with all its saline, earthy, and acidulous ingredients, the aggregate mass *would have been precisely of the same description as was the original water at the close of the period of non-rotation.* This is quite undeniable. And, consequently, there would have been no more water in the ocean than would have sufficed to have held the associated ingredients in chemical equilibrium. Therefore (supposing this to have been the case), every drop of pure water thereafter extracted from the broad expanse of the oceanic surface, by the evaporating influence of the heat of the atmosphere, and borne towards the land by means of clouds and winds, would have had the effect of precipitating the saline or earthy ingredient with which it had previously been combined, the remaining water, saturated to equilibrium, being quite incapable of sustaining the salt or the earth which would have thus been set free; and, from the same inability, those saline ingredients would have fallen to the bottom of the ocean—have been lost to the sustentation of animal and vegetable life for ever—and have been incapable of re-saturating the fresh water, which, from time to time, is restored to the general receptacle by means of rivers, rain, &c.

This return of water from the land to the ocean, poured into it from innumerable streams and rivers, being of lighter specific gravity and floating towards the surface, could not, under this supposed state of matters, have entered into re-combination with salts and earths, which had, during its absence, been precipitated to the bottom. The display of wisdom, which was put forth to provide for this apparently insurmountable double difficulty, is equalled, only, by the comprehensive simplicity and beneficence of the method adopted to guard against it, and to remove it entirely. The case stood thus: a level sphere—possessing an external crust of mineral material enveloped everywhere by a shoreless expanse of saline and acidulous water—was to be transformed into a *terraqueous* habitation for man, animals, and plants, which should require occasional supplies of *fresh water*, by means of an atmosphere common to land and sea; and whilst the oceanic water was to be maintained in its saline condition, a proportion of it was occasionally and universally to be made fresh for the continued supply of the beings and other formations which were to be willed into existence; the two kinds were, mutually, to act and react upon each other, so as each should be preserved in a state of healthful usefulness; and a MEASURE was to be found for that portion of the primeval water which was to be made fresh. This appears to have been the complex problem which

analysis of the water of the ocean has been made, it is found to consist of the *same ingredients*, and in the *same relative proportions*, the strongest proof of static equilibrium. Refer, in confirmation, to the *sixty-ninth* Theorem.

was to be experimentally solved, and which was by the power and wisdom of the Creator successfully accomplished; as, indeed, we never could rationally suppose it would be otherwise.

Although, from the static constitutional condition which the primeval water had attained towards the close of the non-rotatory period, it could neither dissolve nor chemically suspend more saline or earthy ingredients; yet *there was nothing in the composition of the mass to render an addition of* FRESH *water inimical to it.* On the contrary, the salts and earths could thereby be more effectually held in solution. A proportion of the water, then, was required to be made fresh. But how was it possible that part of an illimitable ocean should be made fresh whilst the residue continued salt? It was *not a reduction of the quantity* of original salt water covering the surface of the globe which was desired; but that, while *the entire aggregate quantity of water should remain the same throughout the earth, part thereof should be made fresh, and part should remain salt;* and that a *determinate scale of proportion* should be established between the one and the other; so that, while they existed in due balance, they should be allowed free intercourse with each other—the saline occasionally to act on the fresh—the fresh to produce its effects upon the saline.

The first means adopted towards the accomplishment of this wonderful process, was to cause the earth to revolve around its axis. The next, to expand its surface and to corrugate it into continental elevations and oceanic depressions. Then, to deepen the mass of waters towards the equatorial regions, by withdrawing them from the polar regions. Afterwards, to stretch out the firmament over both land and sea; to apply sudden and intense heats to that portion of the primeval water which corresponded to the spaces occupied by the continents; and, by means of the different affinities for caloric which salts and earths have, when compared with water, to drive off the latter, in its vaporous state, into the newly-formed atmosphere, and to leave the saline and earthy associates *embedded in solid form in the earth.*

No one can contemplate this mighty operation, in which secondary causes were constrained by the Omnipotent to fulfil his wise and benignant designs, without being struck with the simplicity and grandeur pervading the whole! Every stage which the creation underwent, as it advanced towards completion, was immediately made an instrument, first, for the preparation, and afterwards for the accomplishment of that which was to follow. No example, of this kind, is more fraught with instruction than that which was shown forth by the separation of the surplus water from off the land. Fresh water was not only formed by vaporization, and re-united in this state to the great remaining reservoir of saline water of the ocean, whereby this was for ever afterwards enabled to afford a supply of the same material for the future productiveness of the

terraine portion, and for the uses of its inhabitants; but the saline materials, previously combined with the water so driven off, were left in solid store upon the land, where they could afterwards be easily obtained and applied to necessary purposes, while *the land portion of the earth itself* was employed as a standard whereby to mete out the quantity of fresh water to be poured into the sea; and thence to be taken again to irrigate the very land which measured it out from the primeval ocean!

The successful illustration of this part of the subject enables me to make the following observations:—

According to the Dynamical Theory—and to it alone—there were, at the period of the first rotation, intense *heats*, and enormous quantities of *saline material* to be accounted for.

The elevation of the continental ridges and mountain chains having been attributed to the diurnal *motion*, as *motion* inevitably occasions *friction*, and *friction* amongst material masses causes *heat*, and as the introduction of *heated mineral masses* into the midst of waters impregnated with *saline* ingredients, and especially when surmounted by an uncharged atmosphere, would assuredly cause *vaporization* and *separation* between the salts and their *aqueous* solvent; consequently, for all these reasons it was necessary, in order that no flaw might be found in this theory, to account for the expenditure of the remainder of those fierce heats, thus raised, after they had been employed in fusing and charring the rocky masses themselves, in forming the veins, and dykes, &c., and this was done by showing, that it was expended in vaporizing the aqueous portion of the amosphere, and in separating and driving off fresh water, in the state of steam, from its saline associates over an extended area of not less than one-third of the entire surface of the earth. But this, true and natural as it is, only brought us into another difficulty. For it showed, that there was a new and a vast accumulation—the solidified saline residia of this very vaporizing operation—namely, rock-salt, sal ammonia, gypsum, green vitriol, nitre, natron, borax, saltpetre, alum, and perhaps other substances to be accounted for.

And on turning to geology for an elucidation, it was found, that its indefatigable followers had, in the course of their researches, discovered immense deposits of these very saline materials, but whose origin they were at a loss to explain. In fact, they could not account for them at all. They were, of course, immediately laid claim to as the *natural* results of the operation of those primary causes which this theory had been unfolding; while the coincidence itself is offered as a striking manifestation of *the soundness and sufficiency of the principles which have been laid down in it from the commencement.*

The fundamental assumption all along entertained in this theory, that it was not until the land and sea were separated from each

other on the *third* day; when the former, standing out in bold relief with all its variety of hill and dale; the latter washing its newly-formed shore with its sparkling briny element; and the pure and healthful atmosphere, surmounting both, to enable the land and sea to act and react on each other, and together on their common canopy; that these three great divisions of nature were thoroughly completed; is fully borne out by the records of philosophy, which afford a most direct, though, perhaps, unconscious proof of the correctness of the conception entertained; for it is therein asserted, that a mutual and intimate relationship subsists between the atmosphere, the land, and the sea; that these two last have, in turn, a reciprocal effect on the fluctuations and circulation of the atmospheric currents; and that, unitedly, they conspire to the health and to the existence of the animated beings and plants which inhabit the land and by which it is clothed; while the reverse of this aspect is equally as convincing, namely, that no combination of any two of these three great elemental bodies can produce any effect whatever, without the assistance of the remaining one.

"The great instrument of communication," observes Professor Buckland, "between the surface of the sea and that of the land, is the atmosphere, by means of which a perpetual supply of fresh water is derived from the ocean of salt water, through the simple process of evaporation. By this process water is incessantly ascending in the state of vapour, and again descending in the form of dew and rain. . . . . . As soon as springs issue from the earth, their waters commence their return towards the sea; rills unite into streamlets, which, by further accumulation, form rivulets and rivers, and, at length, terminate in estuaries, where they mix again with their parent ocean. Here they remain, bearing part in all its various functions, until they are again evaporated into the atmosphere, to pass and re-pass through the same cycles of perpetual circulation."*

"In the adjustment," says the same author, "of the relative quantities of sea and land in such due proportions as to supply the earth by constant evaporation, without diminishing the waters of the ocean; and in the appointment of the atmosphere to be the vehicle of this wonderful and unceasing circulation; in thus separating these waters from their native salt (which, though of the highest utility to preserve the purity of the sea, renders them unfit for the support of terrestrial animals or vegetables) and transmitting them in genial showers to scatter fertility over the earth, and maintain the never-failing reservoirs of these springs and rivers, by which they are again returned to mix with their parent ocean; in all these circumstances we find such evidences of nicely balanced adaptation of means to ends, of wise foresight, and benevolent intention, and infinite power, that he must be blind indeed who refuses to recognise in them, proofs of the most exalted attributes of the Creator."†

"Climate, in its wider sense," observes Professor Whewell, "is not one single agent, but is the aggregate result of a great number of different agents, governed by different laws, producing effects of various kinds.

* Bridgewater Treatise, vol. i. pp. 557, 558.
† Vindici Geologici, p. 13. Also Bridgewater Treatise, vol. i. pp. 570, 571.

The steadiness of this compound agency is not the steadiness of a permanent condition, like that of a body at rest, but it is the steadiness of a state of constant change and movement, succession and alternation, seeming accident and irregularity. It is a perpetual repose, combined with a perpetual motion; an invariable average of most invariable quantities. . . . . . The principal constituents of climate are, the temperature of the earth, of the water, of the air, the distribution of the aqueous vapour contained in the atmosphere, the winds and rains, by which the equilibrium of the atmosphere is restored, when in any degree disturbed."*

And, at another part of his Treatise, he says—

"The coldness of the atmosphere, and other causes, precipitate the moisture in clouds and showers, and in the former as well as in the latter shape it is condensed and absorbed by the cool ground. Thus a perpetual and compound circulation of the waters is kept up; a narrower circle between the evaporation and precipitation of the land itself, the rivers and streams only occasionally and partially forming a portion of the circuit; and a wider interchange between the sea and lands which feed the springs, the water ascending perpetually by a thousand currents through the air, and descending by the gradually converging branches of the rivers, till it is again returned into the great reservoir of the ocean. . . . . . A due distribution of these circulating fluids in each country appears to be necessary to its organic health, to the habits of vegetables, and of man. We have every reason to believe that it is kept up from year to year; as steadily as the circulation of the blood in the veins and arteries of man. It is maintained by a machinery very different, indeed, from that of the human system, but apparently as well, and, therefore, we may as clearly say, as that adapted to its purposes.

"By this machinery we have a connexion established between the atmospheric changes of remote countries. . . . . . The properties of water with regard to heat, make one vast *watering engine* of the atmosphere."†

"We may observe," he continues, "that the aerial atmosphere is necessary as a vehicle for the aqueous vapour. Salutary as is the operation of this last element to the whole organized creation, it is a substance which would not have answered its purposes if it had been administered pure. It requires to be diluted and associated with dry air to make it serviceable."‡

"It would be probable from this reflection alone, that, in determining the quantity, and the law and interstices of earth, water, air, and heat, the same regard has been shown to the permanency and stability of the terrestrial system, which may be traced in the masses, distances, positions, and motions of the bodies of the celestial machine."§

Perspicuous and satisfactory as the preceding observations are, I cannot refrain from noticing, that their substance has been summed up and expressed, ages ago, in one brief sentence:—

"All the rivers run into the sea; yet the sea *is* not full: unto the place from whence the rivers came, thither they return again."‖

* Professor Whewell's Bridgewater Treatise, pp. 75, 76. † Ibid, pp. 83—85.
‡ Professor Whewell's Bridgewater Treatise, p. 97. § Ibid, p. 109.
‖ Ecclesiastes i. 7.

Several meteorological writers, struck with the wonderful adaptation of the elements, have expressed themselves in becoming terms of admiration and thankfulness, when they contemplated the wise and the benignant arrangements which have been made, by the machinery of the weather, for the well-being of creation.

"The rainy season," says Mr. Hutchinson, "is obviously a providential arrangement in creation to serve a useful purpose. Clouds, during its continuance, moderate the warmth, by acting as screens to intercept the scorching rays of a vertical sun, while the temperature of the earth is further mitigated by the descent of rain, and by evaporation from its moistened surface. Thus, we see, that the rains, which are indispensably necessary in order to vegetation, occur in accordance with the prospective wisdom and beneficence manifested in all the other arrangements of nature, at the season of the year when their cooling influence is most required."

And again, when treating of dew, he observes:—

"In consequence of dew resulting from the depression of temperature, arising from radiation, it falls most copiously on those places where the surface of the ground is best fitted for radiating caloric. Hence, agreeably to the beneficent designs of Providence, by which scarcity produces proportionate economy, and by which all phenomena are adapted, upon the wisest principles to serve useful purposes, frugality in its distribution is observed to be proportionate to the smallness of its quantity." . . . . .

"This fluid," says Dr. Wells, "appears chiefly where it is most wanted, on herbage and low plants, avoiding, in great measure, rocks, bare earth, and considerable masses of water. Its production, too, by another wise arrangement, tends to prevent the injury that might arise from its own cause; since the precipitation of water upon the tender parts of plants, must lessen the cold in them that occasions it."*

"Clouds," says Dr. Prout,† "are one of the great means by which water is transported from seas and oceans to be deposited far inland where water would otherwise never reach. Clouds also greatly mitigate the extremes of temperature. By day they shield vegetation from the scorching influence of the solar heat; by night, the earth, wrapt in its mantle of clouds, is enabled to retain that heat which would, otherwise, radiate into space, and is thus protected from the opposite influence of the nocturnal cold. These benefits arising from clouds, are most felt in countries without the tropics, which are most liable to the extremes of temperature. Lastly, whether we contemplate them with respect to their form, their colour, their numerous modifications, or, more than all, their incessant state of change, clouds prove a source of never-failing interest, and may be classed among the most beautiful objects in nature."‡

These conclusions, so illustrative of the development of the great plan of creation; the distinct and prominent separation of the land from the sea; and the stretching forth of the atmosphere over both, these, acting on each other so as to produce the wholesome and essential vicissitudes of weather, and the necessary recurrence of warmth and moisture, conspire unitedly *to determine the precise*

* Dr. Wells's Essay on Dew.

† Bridgewater Treatise.

‡ Principles of Meteorology, pp. 146, 177, 222, 223.

period of their common origin. To produce these results, it was absolutely essential that a *sphere,* covered with *saline water, should be put into rotatory motion. None but these conditions could have been attended by the resultant consequences which are now experienced.* A non-rotating sphere only could have been *everywhere* covered with water.* The water which everywhere covered a sphere could only have been of *one* kind. That which primarily enveloped the earth could *not* have been without saline materials. Of this we are assured by reasoning *a priori,* confirmed by the senses; for had it been *free* from these, there could not have remained any saline deposits in the terraine portion; nor could the present saline condition of the oceans have been accounted for; while the character and composition of the deposits prove, that the portion of water which corresponded to that part which is now land, if not actually saline, contained saline elements; consequently, if one part was of this description, the *whole* of the primeval water which enveloped the non-rotating sphere, having been all of one kind, must of necessity have likewise been impregnated with salt.

The original water, therefore, which surrounded the earth at "the beginning," contained the elements of salt in association with itself.†

The only method known of producing a thorough and sudden separation between water and its saline associates, is by the application of heat to the mixture. But, "as the same causes produce the same effects," had the heat been *equally* applied to the *whole* of the ancient water, an entire separation between it and the saline ingredient would have taken place alike over land and sea. The separation, however, was partial; and so surely as it *did not* take place to any extent in those portions of the waters which constitute our present seas, so surely *did* it take place in those which surmounted at one time the continents and other prominent parts of the earth, for, *in these latter there still remain, deeply imbedded in the soil, solidified deposits of precisely the same saline description, which, by their union with the vast aqueous reservoir, the ocean, confer on it its distinctive saltness;* and preserve it in its destined condition of salubriousness and utility.

This brings me to a point which shows, that to the universally encircling mass of saline water which accompanied the non-rotating earth, heat of sufficient intensity and extent was applied *partially;* whereby part was rendered *fresh,* by being driven off in aqueous vapour, leaving behind its saline associates, while the major part remained in combination with those ingredients; and no cause commensurate to this stupendous, yet discriminating effect is known save the friction produced by the elevation of continents and moun-

* *First* and *tenth* Theorems and their evidences.

† In a previous part of this work, it has been endeavoured, and I trust successfully, to make apparent the difference between the present "seas" and water holding saline and earthy elements in solution.—AUTHOR.

tain chains thrust up from beneath; and, even, in many instances, along with the stratified mineral masses which formed the spherical crust of the earth, by the centrifugal impetus occasioned by the protorotation of our planet around its axis. No secondary cause, short of this, can be adduced as at all sufficient for this great undertaking. While this supplies the measure required, being fully commensurate to the work performed; therefore, the conclusion is, that the formation of the atmosphere, and the separation between the land and the sea, took place while as yet the influence existed of the centrifugal impetus, occasioned by the first rotation of the earth around its axis. This involves, as a necessary corollary, *that there was a period, however evanescent, when the world was not impressed with diurnal motion;* which, being once admitted—and after what has been said, it seems unphilosophical to deny it—it may as well be conceded, that the sphere existed in its non-rotatory condition for a period, whose duration was sufficient to accomplish that which its want of diurnal motion was intended to produce; quiescent tranquillity being one of the most essential requisites for promoting stratification. And as the mineral masses, whose movement caused the friction which evolved the heat necessary to drive off the fresh water from the sedimentary salts found associated with the red sandstone, oolitic, and other kindred formations; as well as the nitrogen required to form the atmosphere, and the peculiar material, whatever it be, required to constitute the etherial fluid,* were the products of the accumulation of a succession of ages; the argument has by this convergent approach, reached the same common and comprehensive termination, as by all other previous lines of argument, namely, *that the earth revolved around the unillumined sun for a long but indefinite period before rotatory motion was impressed upon it.*

* Dr. Thomson, when treating of this attenuated elastic fluid, says, "shall we seek for the cause of this celestial temperature in the presence of an ethereal fluid, *sui generis*, existing above our atmosphere and pervading space? Of such a fluid, however, we possess no positive knowledge."—(Page 72.)

SECTION VII.

COMPLETION OF THE ATMOSPHERE; SEPARATION OF THE SEA FROM THE LAND; AND THEIR IMMEDIATE COMBINED RESULTS.

CHAPTER XXXV.

The newly-formed atmosphere a receptacle for the elements which constitute the phanogamous class of plants; and afterwards for nourishing and sustaining them. The subject of the preceding chapter applied to the present. Supernatural action of Light in and during the formation of this division of the Vegetable Kingdom. Reflections which this display of great power necessarily occasions. This chain of reasoning confirmed by quotations from Botanical writers. Further evidences in favour of the Dynamical Theory deducible from the existence of distinct Botanical districts throughout the earth's surface. Scientific confirmation of these assumptions; and the regions defined in which the phanogamous classes abound. Combination of these truths with those formerly wrought out, applied to prove that the Earth, in perfect accordance with this theory, received from the hands of the Creator, on the first day of the Mosaic week, the identical inflexions of surface which it still retains.

I SHALL commence the present chapter by directing the attention to the further use made of the newly-formed atmosphere, in nourishing and sustaining the numerous and diversified objects of the vegetable kingdom, which clothed and embellished the naked land, thus brought out in such bold relief from "the seas," which were then gathered together within their assigned and predetermined limits.

The first points to which the attention has to be directed, are the appropriateness of the juncture at which the phanogamous division of the vegetable kingdom was called into existence; and the adaptation of the elements, then existing, to its formation. It being assumed, *that when a work of this kind is delegated to any agent*—as this was to the earth*—*the means to carry it into effect would be duly provided and placed by the Creator at the disposal of that agent*; likewise, *that the concomitant circumstances would be auspicious for the performance of the command.*† The state of the earth, at the period

* Genesis i. 11, 12.

† This, which is a fundamental assumption of the theory, has already been proved to be a sound one.

when it is recorded that this part of the vegetable kingdom was willed into existence, will satisfy us that this assumption is correct. The component elements of almost all the organised objects which constitute the vegetable kingdom may be reduced to three ultimate principles, hydrogen, oxygen, and carbon. Of these, together with a few peculiar salts in small quantities, and of a minute proportion of nitrogen found in some peculiar families, the whole of those interesting, varied, and useful objects of nature are entirely composed.*

The two first of these elementary and necessary ingredients were abundantly provided for by the aqueous vapour with which the atmosphere was saturated, in the manner so lately explained; while the carbon, the remaining essential requisite of the vegetable kingdom, would be plentifully supplied by the carbonic acid, liberated by heat from the fused masses of limestone intermixed in the rocky elevations which had been thrown up to form the terraine portion of the globe; the associated lime having been disengaged to assist in composing the soil which was deputed to produce them. For it will be seen, by referring to the *hundred and second* Theorem, that the application of fierce heat to the carbonate of lime, or common limestone, disunites the calcareous earth from its acidulous associate, both of which, in this instance, were useful; indeed, could not be dispensed with. And thus it is seen that the provident wisdom of the Creator had provided all the requisite materials before he issued the command—"Let the earth produce grass; the herb yielding seed: and the fruit tree yielding fruit, whose seed is in itself upon the earth." Indeed such are the fundamental characteristics of this theory, that unless some vast operation, such as the embodying of the whole phanogamous division of plants had been undertaken, it would have failed in accounting for the extra carbonic acid which abounded at the particular period to which allusion is now made.

But there is still to be unfolded, with marked effect though in brief detail, circumstances which point in a peculiar manner to the appropriateness of the *juncture* when it pleased the Creator to will into existence the flowering, seeding classes of the vegetable kingdom recorded to have been formed at this time. It has been already shown that the requisite materials were prepared in great abundance and held in readiness; and it is now, in continuation, to be seen that a commensurate receptacle for them, and suitable means for their ready conveyance, were also provided. *This was the newly-formed atmosphere*, peculiarly well fitted, both by its nature and universality, for maintaining in proximity the aqueous vapour and carbonic acid wherever plants were to be formed by the delegated command which the earth had just received. Next, the vegetable kingdom was called into existence while as yet the light and heat—

* Edinburgh Journal of Natural History. Murray's and Reid's Chemistry. And Todd and Bowman's Anatomy of Man, &c. &c.

the principal agents in fixing the woody fibre—were *not concentrated* around the sun, or constituted as they are at present; for in *that* case there could not have been the quantity of these requisites for this operation supplied *within the time specified;* while, for other and essential reasons it should be clearly borne in mind, that the light employed in conferring vegetable vitality was *different in kind* from that which was afterwards employed in forming the animal kingdom, and supplying *its* stream of nervous fluid. And, lastly, the introduction of this kingdom of organic objects was with as much wisdom and goodness *deferred* until this particular juncture, as it was most benignantly interposed between the formation of the continents and that of the animated beings destined so soon to follow. Because, in the elevation of the former, during which there was so much carbonate of lime present, and so much heat evolved by friction, the consequent extrication and suffusion of immense quantities of carbonic acid were unavoidable, and would have proved prejudicial, if not positively destructive, to the lives of the creatures constituting the animal kingdom, had not the vegetable forms preceded them; towards whose formation that pungent and life-destroying gas is as favourable and conducive as it is prejudicial to *animal* existences.

In following up the argument, the first thing to which the attention requires to be directed, is the well-grounded assumption that there must have been a decided difference of character between the plants which were created during the non-rotatory period, and those willed into existence in the Mosaic week; because atmospheric air, which did not exist until then, is essential for the growth and perfection of innumerable orders of plants, which could not, it is presumed, have existed before the completion of what was so essential to their well-being. Under this impression, let the *hundred and eighteenth* Theorem be recapitulated, "*That all the phenomena attending the flowering of plants, and the dehiscence of the various receptacles which are instrumental in the fertilization and maturation of the seed and fruit, and the dissemination of the former, fully attest the absolute necessity of these complicated operations being conducted in atmospheric air; the presence of much moisture being prejudicial to the peculiar development of the pollen.*" And, in continuation, we adduce what is stated in the succeeding Theorem: "*That immediately after the flower has become fully expanded, some portions of it begin to decay; but the ovarium, and sometimes the calyx, and other parts continue to grow, and assume a very different appearance—they become the fruit; while the ovula, having been subjected to the fertilizing influence of the pollen, also undergo certain remarkable changes, and become the seed.*

"*That these fruits, thus enclosing their seeds, assume a great variety of forms and characters, some being soft and pulpy, others hard, woody, dry, and membranaceous; but, in general, they may be classed under some one or other of the following denominations, namely:—the legume;*

the drupe; the nut; the akenium; the glans; capsule; gourd; berry; pome; samara; or the siliqua."

Truths so apparent, that nothing but the chracteristic of this work—exactitude—could have induced their having been brought forward; and leaving it, therefore, to those who may have any remaining doubts, to look into the coincidence of the evidences quoted in support of these theorems, I shall proceed to make the application in support of the general argument for which they were adduced. It is this, that as the leading difference between the phanogamous plants—comprising the classes monocotyledons and dicotyledons—and the cryptogamous plants or acotyledons, consists in the two former possessing flowers and perfect seeding apparatus, while the latter is destitute of both; and atmospheric air being indispensably requisite for the growth and perfection of Flowers, Seeds, and Fruits, it follows as a correct deduction, that plants of the *phanogamous* kind could not, by any possibility, have existed previous to the formation of the atmosphere. And as the atmosphere, according to what has now been explained, could not have existed before the formation of the light, and the revolution of the earth around its axis, it follows, as a matter of course, *that phanogamous plants could not have existed previous to the diurnal rotation of the earth.* But it has been made as apparent as the evidences of the senses will permit, that long previous to the formation of the atmosphere, to the calling forth of the light, or to the rotation of the earth around its axis, the sub-aqueous surface of our planet abounded with plants. By the dexterous blending of these two classes of truths, it follows, that those which primarily existed, *were not flowering plants;* and if not flowering plants, they could neither have produced seeds, nor fruits with seeds in themselves; because to produce seeds, or fruit with seeds, flowers must precede; and if destitute of seeds, they were not included in the last command issued on the third day, because all the plants mentioned in it either produced seeds, or fruits with seeds in themselves. And thus the word of God is alike consistent with itself in all its various parts; and perfectly accordant with the existing laws of nature, as manifested by the announcements of natural philosophy in its several ramifications.

This leads, in turn, to a well-grounded presumptive inference, that as light and atmospheric air exercise their influence principally on the floral envelopes of plants, and on the seeds and fruits, which, in due time, proceed from these interesting and beautiful vegetable expansions, it may thence be concluded, that the plants of the non-rotatory period were deficient in these peculiar organs. Light and atmospheric air not then existing, they could not have been brought to perfection. And although it is still an important desideratum in botany to determine which families of plants are, in reality, *seedless*, yet it is to be inferred, that such as are so, were known to the inspired historian to have existed previously to the formation of the

flowering classes; inasmuch as he expressly mentions the *creation of the earth*, and this, we know, proceeded in part from their secretions and fossilized remains.

The attention will next be directed to an enumeration of the principal elements which contribute to the formation of vegetable textures, especially to those which are essential for the construction of woody fibre. With this design, I shall recapitulate the *forty-fourth*, and afterwards the *hundred and twenty-fourth* Theorems, both of which being relevant to the same subject; the evidences common to them, which bear directly on the point to be substantiated, shall be adduced. The former states:—

"*The quantity of water lost to a plant by evaporation, and its power of absorption from the soil, are in proportion to the quantity of light. Light causes the decomposition of the carbonic acid of vegetation; and by solidifying the tissue, renders the parts most exposed to it the hardest. And the green parts of plants, when exposed to the direct light of the sun, absorb from the atmosphere carbonic acid, which they decompose, and give back the oxygen.*"

The *hundred and twenty-fourth*, nearly to the same effect, states, "*That besides the carbonic acid elaborated by plants within themselves by means of the oxygen imbibed from the atmosphere, and by the carbonaceous matter contained in their sap, they absorb it also from the air, and receive it combined with the water taken in by their spongioles; and that so long as plants remain in the dark, the greater part of the carbonic acid is retained, but not fixed in the form of an organic compound until stimulated by the light, when its decomposition is effected; the carbon becomes fixed, and nearly all the oxygen with which it was united is exhaled into the atmosphere.*"

The third section of this work having been chiefly dedicated to the physiology of certain parts of plants, on the present occasion, when adducing the conjoint evidences for the above theorems, I shall dwell more particularly on those affecting the fixation of vegetable matter, and the formation of textures peculiar to the objects of that kingdom of nature.

"When the food of a plant enters the roots," observes the writer on Botany, in the Cabinet Cyclopædia, "it passes upwards, undergoing some kind of chemical change, and dissolving whatever soluble matters it meets with in its course; so that without having been exposed to any of those conditions by which it is ultimately and principally affected, it is considerably altered from its original nature before it reaches the leaves. . . . . . A portion of the water which plants suck up combines with the tissue and enters into the general constitution, where it becomes fixed as the waters of crystalization in minerals. . . . . . Under what influence, except that of the vital principle, a decomposition of the sap takes place before it reaches the leaves, we are ignorant. But when it has reached the leaves, and thus becomes exposed to the effect of light, ... *we find that light causes a decomposition of the carbonic acid of vegetation, and consequently, by solidifying the tissue, renders the parts most exposed to it the hardest.* . . . . . That the quantity

of water lost to a plant by evaporation is in proportion to the quantity of light is easily proved by the experiment mentioned by De Candolle. . . . . Whatever doubt there may be concerning the precise causes of evaporations, there can be none whatever as to the power which sunlight has to cause the decomposition of carbonic acid, the fixing of the carbon, and the giving out of oxygen. . . . . . For, however varied experiments may be, they all lead to the same result, and compel us to acknowledge the great importance of light to plants, in enabling them to digest the crude matter which they gain from the soil. In fact, there is nothing of which we have any certain knowledge that interferes with these conclusions."*

"When all those parts of plants," according to Professor Henslow's popular treatise, "which are capable of assuming a green tint, but more especially the leaves, receive the stimulus of light, they immediately decompose the carbonic acid contained in the sap. The result of this action is the retention of the carbon, and the expiration of the greater part of the oxygen into the surrounding atmosphere. . . . . . The fixation of the carbon by plants appears to be the first step in that elaborate process by which brute matter is converted into an organizable compound; that is to say, into a material capable of being afterwards assimilated into the substance of an organized body. Many effects, popularly ascribed to the action of air, are, in fact, due to the agency of light. . . . . . When we proceed to enquire in what form the carbon appears after it has become fixed, the subject assumes a degree of uncertainty, which it seems almost hopeless to get rid of in the present state of our knowledge. . . . . . Unluckily for our enquiry, there are so many different compounds contained in solution among the sap and various juices of plants—such as gums, sugars, resins, oils, acids, alkaloids, &c., all of which are composed of different modifications of the same three elements, carbon, oxygen, and hydrogen—that it becomes a task of the greatest delicacy to determine which of them ought to be considered as the immediate result of the process of fixation. . . . . . But we find, upon more careful enquiry, that our choice is restricted to about four substances, all of which possess nearly the same chemical characters, and which are the most universally present among the juices of plants. These are gum, sugar, fecula, and lignine. The first of these appears by far the most universally diffused, and has been obtained from nearly every plant in which it has been sought for; and, moreover, as it possesses decidedly nutritious qualities, it may be considered, with every probability in its favour, as the first or proximate organizable compound, formed by the action of vegetable life, acting under the stimulus of light."†

Having been informed, by these evidences, what are the elements which enter into the construction of plants, and the manner in which they are solidified by the effectual influence of sunlight; the scope of the argument requires, before concluding the chapter, to direct the attention to seemingly a very homely and well-attested truth, declared in part of the *hundred and twenty-first* Theorem, namely, "*that the time required to admit of plants arriving at maturity varies from some weeks to several years.*"

As this is a fact so well known by all—and writers on botany have seldom occasion to refer to it except by assumption—it must

* Botany, in Cab. Cyc. pp. 84, 85. † Ibid, pp. 189—191.

either be admitted, merely on the authority of the theorem, or proved by the duration, or by the assumed period for the maturation of the several orders and genera of the phanogamous classes of plants throughout the world. I feel inclined to rely on the former method of authenticating the assertion, being convinced, that it coincides so closely with the experience of all who are in any manner conversant with botany or horticulture, as to require nothing beyond its mere enunciation to be taken for granted.

The period, then, necessary to mature the objects of the vegetable kingdom is never shorter than several weeks; and in numberless instances is prolonged to as many years; and it is requested that this fact, although trite and commonplace, may be borne in mind, as it will be pretty heavily leant upon in the immediately subsequent reasoning.

Considering the mind to be properly instructed with respect to the two distinct subjects which have just occupied the attention, that is to say—the ponderable and imponderable elements which enter into the composition of vegetable texture and woody fibre; together with the manner and process of their acting on each other, and of being elaborated into these forms; and on the other hand, the usual time required to bring the objects of the vegetable kingdom to perfection and productiveness; I shall now, in continuation, endeavour, by their careful combination, to elicit another important truth, namely—that to enable the earth to produce and bring to perfection the whole of the vegetable forms, which clothe and adorn its surface, in the brief period of one day, there must have been a *supernatural* power conferred upon it; an *extraordinary* supply of material placed at its disposal; and, likewise, a commensurate suffusion of light and heat communicated; to the intent, *that the vast accumulation of material, thus provided, should be decomposed, assimilated, and fixed into the form and substance of full grown herbs and fruit-bearing trees, within the time specified.*

Perhaps, this may be thought rather an advanced position on the part of a creature, as if tending to circumscribe, by attempting to reduce to the standard of our puny conceptions, the ways and the workings of a Being whose every act is, and must ever essentially be, supernatural; and, consequently, not capable of being limited by our conceptions. Impressed, however, with the conviction that *faith is not incompatible with observation and common sense, when employed in the contemplation, and in the reconciliation of the Record with the works of creation*, and fully convinced, that laws once established by the Creator are ever afterwards respected by Him, and taken into account in all that is done *subsequently* to their promulgation; it may clearly be apprehended, that it being deemed necessary *to delegate to the newly-formed earth* the miraculous faculty of bringing forth the phanogamous or flowering part of the vegetable kingdom, at once and in perfection, we may look upon the objects which were pro-

duced in their true acceptation, as the stock or progenitors of all the orders of the flowering, seeding, or fruit bearing plants, the *material, tangible* objects of the phanogamous division of the vegetable kingdom, and conclude, clearly and decidedly, that although the power to produce them was *supernaturally* and only for once conferred on the earth, and the elements then present were in *quantity preternaturally* brought into juxtaposition, yet the materials themselves were *natural,* were produced by natural agents; elements so *made to abound,* as they then were, and for that *special occasion,* never afterwards to be repeated. Having, by a similar process of reasoning, been enabled to satisfy the mind, that sources sufficient to yield these extra supplies of hydrogen, oxygen, and carbon, did exist at the time alluded to, it becomes, likewise, convinced, that there was a source from whence there could emanate a greater supply of LIGHT and HEAT than now comes in one day, or in a part of a day, from the sun; and which being required, was sufficient to work up these materials. Therefore, it is re-asserted, that the quantity of light employed in producing and perfecting the vegetable kingdom, on the third day of the Mosaic week, *was supernatural,* and that it has never been so communicated again, since the remainder of the light has been concentrated around the sun, in order to be imparted to the planets of the system *in quantities* whose amounts can be computed by the *time.**

To render obvious the assumption thus made—that it was an application, and an effect of the primary light before it was concentrated around the sun—in the extraordinary quantity required, which wrought up the vegetable elementary matter, then made to abound for the purpose, there should, first of all, be considered generally, that the expansive principle of light was that which the Omnipotent chiefly employed during the whole period designated as the Mosaic week. It was the electro-magnetic energy of light which caused the earth to revolve around its axis, and to occasion the first night and day. It was its expansive principle, which, united to the pre-prepared elements, made the firmament to stretch forth as a garment; the same subtile and buoyant power, when combined with the aqueous elements, dispersed the necessary vapour throughout the heavens; and it also was light which effected the separation between the land and the sea. By the evidence of modern botanists, it has been shown that it is, even now, light and heat which are chiefly instrumental in forming and consolidating vegetable fibre and texture; and it must never for a moment be forgotten that it is not because it does so *now* that it did so *then,* but the reverse. Light and heat are the means, now, of forming and consolidating vegetable elements into woody fibre, because, at the eventful period alluded to, it pleased the Creator, as one of the progressive fundamental laws of nature, that light should be made his

* According to the tenor of the *second* Theorem and evidences.

agent, in forming and completing those variegated and interesting objects, the phanogamous classes of the vegetable kingdom, which were then to be brought into existence.

With respect to the previously formed *cryptogamous* plants, whose reproductive organs are mere sporules, or analogous receptacles, possessing neither radicle nor plumule, and quite indifferent to polar energy, being such as were not comprehended in the terms, "herb bearing seed, and fruit-tree yielding fruit whose seed is in itself upon the earth," I would, before continuing the general argument, make a few brief observations.

The earth having been empowered, with the aid of the elements placed at its disposal, to produce the flowering, seeding classes of plants, we are warranted to surmise that the same agent—the earth—was the means which the Creator, likewise, made use of to create the primeval cryptogamous kinds during "the beginning;" and, following up this assumption, to conclude, that in obedience to the more general and comprehensive laws of materialism, those which governed the production of species would be conformable throughout the wide domains of materialism; *the same great principle—the light—having conferred polarity on the earth, and every other rotating spheroid, as well as polarity on every germinating body, even to "a grain of mustard seed!"* When the earth, by protorotation, became endowed with poles, it produced plants whose reproductive organs have radicle and plumule; and whose energies and vitalities propend in different ways, and with relation to polar directions; and pre-supposes the existence of the unseen fluid, which occasions this polar sensitiveness of structure and method of proceeding on the part of the phanogamous plants. But, while the earth lay slumbering in the dark womb of nature, without poles or axis, itself the sporule of a world, it is but consistent to suppose, that it could only confer on the reproductive bodies of other objects—on its then restricted vegetable kingdom—faculties akin to those which itself possessed; a conclusion fully borne out when it is remembered, that the subtile imponderable fluid which occasions polarity had not then been called into existence; and hence, when the common origin, and unity of design in all the works of creation, are taken into consideration, there can be no reason to expect, that the earth, in producing any of them by delegated power, could endow the reproductive organs of the primitive and restricted vegetation with faculties of a higher order, or which required, for their development, the influence of a force to which it had not itself, before rotation, been subjected—which, in fact, did not exist. For this would be to presume a crude anomaly in the laws impressed on materialism which is nowhere found to be the case. And, therefore, relying on this sound principle, there should, *a priori*, have been expected what experimental botany, when applied to the extinct fossil vegetation, has revealed as actually existing, namely, that the fossil objects of the vegetable

kingdom, considered as belonging to that remote era and condition of the globe, when brought into comparison with recent equivalents, are found to belong to those orders whose reproductive organs are indifferent alike to polarity, or to the putting forth of vegetative energies in the opposite directions of *radicle* and *plumule;* but send forth their expansions from whichever side mere casualty brings into contact with the ground. And it is thus, when the whole works of creation are viewed as emanating from the same Omnipotent source, that we are best able to estimate their comprehensiveness, to perceive all their beauties, and be convinced of the thorough and harmonious consistency of the one with the other.

"It must be obvious, on consideration," says the practical author of Botany, in the Library of Useful Knowledge, "that plants in which there exists neither stamens nor pistils, and in which there cannot take place any of those phenomena we have lately been examining, when treating of phanogamous plants, must also be destitute of seeds; . . . . . . but if they have not reproductive organs, like those of plants of a higher organization, they are furnished with matter of another kind which answers the purpose equally well. This matter consists of what is called *sporules* or *spores*. . . . . .

"In the more perfect of the tribes of flowerless plants, there can be no doubt that spores act precisely like seeds in reproducing the species. In regard to those of ferns and mosses, no difference exists between seeds and spores, except as to the organ, organization, and mode of development of the latter. Instead of having their centre divided into plumule and radicle, to which one or two cotyledons are attached, they are mere homogeneous masses of cellular substance, and instead of uniformly growing from two constant points of their surface, from one upwards and from the other downwards, they are capable of sprouting into root or stem indifferently from any point of their surface; the nature of the parts which the spores produce depending, not upon pre-existing organization, but upon accidental circumstances. When they begin to grow, that portion of the surface which is exposed to light extends into a stem, and that which is turned to darkness and humidity becomes root."

"Yet," he very appropriately concludes, "we must not be led astray by any ideas of equivocal generation. But in the absence of demonstrative evidence to the contrary, let us believe the great Author of Nature to be consistent with himself in all his works; and to have taken care to enable the most humble *sea weed* to be multiplied by some means as certain and unchangeable as the most stately lord of the forest. We may rest assured, for all philosophy, all observation, and all reason prove it, that there is no such thing in nature as blind chance; but that all things have been carefully and wisely designed with reference to the particular circumstances under which they exist."*

The remarkable persistency of the general law above alluded to, not only serves to corroborate the soundness of the position assumed in this from the first; but, likewise, to make manifest the wise arrangement, and the design of the creation—developed according

* Botany, Library of Useful Knowledge, pp. 117—119.

to one great and comprehensive plan—which subjected the planets of the system, and the sporules of the cryptogamia alike to its power, and its all-pervading influence. And it is, when we are enabled thus to elevate our minds above the trammels which usually confine them, and with a bold yet faithful stretch of imagination, conceive all the works—minute and great—of creation emanating from the same omnipotent source, and rendered subject to the same great and comprehensive laws, that we are enabled to recognize more clearly the adaptation of one part towards the other, and the harmony of the whole.

In the further prosecution of the subject, there is now to be displayed another peculiarity of the vegetable kingdom. In the *twelfth* Theorem, it is stated :—" *That the continents, and even the islands, are found to possess a flora of species peculiarly their own. That whilst a considerable number of plants are common to the northern regions of Asia, Europe, and America, where these continents almost unite, towards the south, where they widely diverge, the floras of these three great divisions of the globe differ very materially, even in the same parallels of latitude. And, that upon the principle of distinct floral foci of creation, the whole earth has been divided, by botanists, into a certain number of botanical districts, differing from each other almost entirely in their specific vegetation.*"

"It seems to be a natural consequence," observes Professor Henslow, with his usual perspicuity, "of our considering the geographical distribution of every species to have taken place by its gradual dispersion from one definite spot on the earth's surface, that some would be found only in one district, and others in another, provided these were separated by some great physical feature, such as a chain of mountains or a wide sea; and that two such districts, though they might lie under the same parallel of latitude, would contain few species common to both. Such districts are termed 'botanical regions." These are spaces enclosing particular species, distributed through them in the stations adapted to their growth; but so encompassed by physical obstructions, that the great majority of species found within their limits are not to be met with elsewhere. . . . . . There are about fifty of these regions whose floras have been partially examined, and of which lists have been given. . . . . . The centres of Africa, Asia, and other unexplored districts probably afford several more. Twelve of these regions enumerated belong to the northern hemisphere, between the pole and tropic of Cancer; twenty-six are intra-tropical; and seven are extra-tropical, in the southern hemisphere. The first are the largest, and approach each other the nearest; the second are less extended, and more frequently separated by the ocean and deserts; the last are very unequal in extent, and above all, more dispersed, many of them being small islands in the midst of an immense ocean. . . . . . Many local circumstances produce remarkable modifications in the relative proportions between the species of different classes and orders, in regions under the same parallels of latitude. Thus, for instance, *cæteris paribus*, the cryptogamic tribes flourish most in moist regions. The places best adapted to the growth of ferns are the islands in tropical climates, in some of which, as in St. Helena, one-half

the flora is composed of them. . . . . . The same causes which appear favourable to the increase of cryptogamic species, seem also to produce a diminution in the proportions which dicotyledons bear to monocotyledons; and other relations of considerable interest have also been pointed out between the species of different orders, occurring in different regions."*

"The gradual decrease of temperature," Mrs. Somerville says, "in the air and in the earth, from the equator to the poles, is clearly indicated by its influence on vegetation. In the valleys of the torrid zone, where the mean annual temperature is very high, and where there is abundance of moisture, nature adorns the soil with all the luxuriance of perpetual summer. . . . . . But the richness of vegetation gradually diminishes with the temperature; the splendour of the tropical forest is succeeded by the regions of the olive and vine; these again yield to the verdant meadows of more temperate climes; then follow the birch and the pine, which probably owe their existence in very high latitudes more to the warmth of the soil than to that of the air. But even these enduring plants become dwarfish, stunted shrubs, till a verdant carpet of mosses and lichens enamelled with flowers, exhibits the last signs of vegetable life during the short but fervent summers at the polar regions. . . . . . It is not in this instance alone that similarity of climate obtains without identity of productions; . . . . . each separate region, both of land and water, from the frozen shores of the polar circles to the burning regions of the torrid zone, possesses a flora of species peculiarly its own. The whole globe has been divided into botanical districts, differing almost entirely in their specific vegetable productions; the limits of which are most decided when they are separated by a wide expanse of ocean, mountain chains, sandy deserts, salt plains, or internal seas. A considerable number of plants are common to the northern regions of Asia, Europe, and America, where the continents almost unite; but, in approaching the south, the floras of these three great divisions of the globe differ more and more even in the same parallels of latitude, which shows that temperature alone is not the cause of the almost complete diversity of species that everywhere prevails. . . . . . It appears from the investigations of M. de Humboldt, that between the tropics the monocotyledonous plants, such as grasses and palms, which have only one seed-lobe, are to the dicotyledonous tribe, which have two seed-lobes, like most of the European species, in the proportion of one to four; in the temperate zones they are as one to six; and in the arctic regions, where mosses and lichens, which form the lowest order of the vegetable creation, abound, the proportion is as one to two. The annual monocotyledonous and dicotyledonous plants in the temperate zones amount to one-sixth of the whole, omitting the cryptogamia; in the torrid zone they scarcely form one-twentieth, and in Lapland one-thirtieth part. In approaching the equator, the ligneous exceed the number of herbaceous plants; in America there are a hundred and twenty different species of forest trees, whereas in the same latitudes in Europe only thirty-four are to be found. . . . . . Various opinions have been formed on the original or primitive distribution of plants over the surface of the globe, but, since botanical geography became a regular science, the phenomena observed have led to the conclusion, that vegetable creation must have taken place in a number of distinctly different centres,

* Botany, in Cab. Cyc. pp. 304—309. It is recommended that the whole passsge should be perused; that given here is merely an abstract.—AUTHOR.

each of which was the original seat of a certain number of peculiar species, which at first grew there and nowhere else. Heaths are exclusively confined to the Old World, and no indigenous rose tree has ever been found in the New; the whole southern hemisphere being destitute of that beautiful and fragrant plant. But this is still more confirmed by multitudes of particular plants having an entirely local and insulated existence, growing spontaneously in some particular spot, and in no other place; for example, the cedar of Lebanon, which grows indigenously on that mountain and in no other part of the world."*

The next step must be to discover, with greater speciality than even these quotations point out, whether any, and what proportion of the flora of these distant centres or foci pertain to the *Phanogamous* division—that is—the *Monocotyledonous* and *Dicotyledonous* classes of plants. With this view, the following evidence will be perused with advantage. Mr. Lyell, with reference to M. Humboldt's personal narrative, gives the following :—

"Every hemisphere," says this traveller, "produces plants of different species; and it is not by the diversity of climates that we can attempt to explain why equinoctial Africa has no laurinia; and the New World no heaths; or why the calceolariæ are found only in the southern hemisphere. . . . . . . We cannot explain why no one family of melastomas vegetates north of the parallel of thirty degrees; or why no rose-tree belongs to the southern hemisphere. Analogy of climates is often found in the two continents without identity of productions.

"In further illustration of the principle above alluded to, that difference of longitude, independently of any influence of temperature, is accompanied by a great and sometimes a complete diversity in the species of plants. De Candolle observes—'That out of 2,891 species of phanogamic plants described by Pursh, in the United States, there are only 385 which are found in northern or temperate Europe. MM. Humboldt and Bonpland, in all their travels through equinoctial America, found only twenty-four species, these being all cyperacea and graminea (monocotyledons) common to America and any part of the Old World.' "

"In the Canaries," continues Mr. Lyell, "out of 533 species of phanogamous plants, it is said that 310 are peculiar to these islands, and the rest identical with those of the African Continent."

And again—

"The entire change of opinion which the contemplation of these phenomena has brought about is worthy of remark. The first travellers were persuaded, that they should find, in distant regions, the plants of their native country; and they took pleasure in giving them the same names. It was some time before this illusion was dissipated; but so fully sensible did botanists at last become of the smallness of the number of phanogamous plants common to different continents, that the ancient floras fell into disrepute. All became diffident of the pretended identifications, and we now find that every naturalist is inclined to examine each supposed exception with scrupulous severity."†

* Connexion of the Sciences, pp. 278—283, necessarily very much abridged.
† Principles of Geology, vol. ii. pp. 71—75.

Professor Henslow says—

"So far as calculations have hitherto been made, the following general laws appear to be correct; and it is not likely they will be much modified by any additional information which future researches may procure:—

"1. The proportion of cryptogamic to phanogamic species, increases as we recede from the equator.

"2. The proportion of dicotyledons to monocotyledons, increases as we approach the equator.

"3. The absolute number of species, and also the proportion of woody species to the herbaceous, increases as we approach the equator."*

The result of this last enquiry enables us so far to modify the conclusion come to in the *twelfth* Theorem, as to pronounce, *that of the distinct flora found, peculiar to the continents and islands of the world, a considerable proportion is* PHANOGAMOUS; and to draw from these facts whatever deduction may be considered proper.

What, then, ought to result from the introduction of these truths amongst the others which have been formerly established? It has been proved, that the different centres or foci of the vegetable kingdom are dependent upon there being detached continents and islands on the earth; that is, they are bound up or connected with the greater inequalities of its surface; while of the plants forming these distinct floral foci, a considerable number pertain to the *monocotyledonous* and *dicotyledonous* classes, or to the *phanogamous* division of the vegetable kingdom. But it has, likewise, been as clearly shown, that these two perfect classes could not have existed previously to the formation of the light and of the atmosphere; that they were indeed called into being through the instrumentality of a *supernatural* suffusion of light, or, in other words, that their formation took place *before* the light was placed, as it now is, in the centre of the system; and it having been declared, that the former of these events took place on the *first*, and the latter on the *fourth* day of the Mosaic week, *we are thus enabled*, by means of the phanogamous vegetable classes, and of distinct floral foci, *to determine the period*, WITHIN THREE DAYS, WHEN THE EARTH RECEIVED ITS ACTUAL DIVERSITY OF SURFACE, AND PRESENT FORM.

This conclusion is based alike on the announcements of scripture, and the experience of scientific research. Those continents and islands, which constitute the detached and distinct floral centres, bearing flowering, seeding plants, must have been formed, and have still retained the form which was given to them *at some period between the first and the fourth days of the Mosaic week*. And if from the latter there be deducted the several increments of time which were occupied in the formation of the atmosphere, in the separation of the land from the sea, and in the production of the phanogamous plants themselves, we shall be thrown back on the *first day of the*

* Botany, in Cab. Cyc. p. 308.

Mosaic week, as that on which the present great outlines and inequalities of the earth's surface were indelibly impressed upon it.

It may be remembered, that in a previous part of this work, it was concluded, that the earth received its actual geographical outlines, in consequence of the first revolution which it performed around its axis, as an immediate effect of the formation of the primary light; and as the deductions from the existence of distinct floral foci point to the same period, another and a very interesting corroboration is thus contributed of the soundness of the former inference. The erratic boulders and blocks, dispersed by the first revolution of the earth around its axis, supply (though occasional and detached), yet widely spread evidences of the origin and permanency of these great inequalities of surface. But the trees, shrubs, and grasses found in distinct foci, furnish a more minutely and closely interwoven web of evidences, which, filling up the interstices and covering the whole terraine surface of the globe, do away with the last refuge for doubt; while the satisfaction, in bringing forward this new series of proof, is greatly heightened by the consideration that such favourite objects in the great repository of nature as the flora, should, by their presence, so effectually contribute to establish the point in question; and afford their humble but undeniable testimony to the truth of those announcements, which proceeded from the common Creator.

These combinations it has been seen have reduced the time to a period whose extent cannot exceed that of three days; on some one of which the earth must have received the more prominent inequalities of surface which it still retains; and resuming the subject, with the design of going more into detail, I shall now endeavour to determine *on which of those three days the change of form alluded to actually did take place.*

The last evidences which have arisen from the phanogamous classes of the vegetable kingdom, enable us to conclude, that both the soil to which they are fixed, and the atmosphere in which they grew, were formed *before* these plants were called into existence; and, in consequence, to eliminate a portion of the ultimate time as being that occupied in the production of those essential elements, the soil and atmosphere, leaving the remainder for the formation of the earth.

Every evidence which has been brought to bear upon the argument, has tended to prove, that the formation of the atmosphere must have *succeeded* the establishment of the *inequalities* of the earth's surface, and not preceded them; because it is more reasonable to suppose, that the aerial ocean was formed *after* these elevations and deep depressions had been made, than that it should have existed while as yet the earth was a sphere; and, therefore, by deducting from the remaining time that which is stated to have been occupied in making and perfecting the atmosphere, and separating, through

its instrumentality, the land from the water, without which these plants could not have existed, *we are carried back to the first day of the Mosaic week, as that on which the earth received the greater inequalities of surface which it still preserves*—a conclusion in the strictest accordance with what has ever been set forth by the Dynamical Theory; and it is to be hoped, that concurring testimonies, drawn from so many separate sources and different branches of science, will carry such conviction to the mind, as shall remove every doubt, and impart that most inestimable of all blessings, perfect belief in the harmony which exists between the WORKS and the WORD of GOD.

I have thus been enabled to arrive at a point where, according to the order of sequence, there appears to have taken place a manifest change in the manner of conducting the process of creation. Hitherto, the light, the chief agent employed, had been in such a state, as to be capable of being imparted in the manner and quantity most suitable for the completion of the works which the Creator contemplated; and which were developed in succession. But from this period ever afterwards the light was so restricted, as to be given forth in fixed and regulated quantities; issuing in equal timely supplies from luminaries placed in the firmament of the heavens, to dispense the light and heat best suited to the wants and comfort of the various inhabitants of the solar system.*

Amongst the numerous motives for wonder and admiration which this remarkable change, in the method of procedure, seems fitted to produce in the mind, perhaps not the least extraordinary is the announcement of its having taken place precisely on the conclusion of those parts of the creation *which may be considered as unendowed with volition:* a coincidence so remarkable between the *period* of this all-important change and the *kind* of beings which were willed into existence thereafter, that, joined to the impression of there being a necessity for the modification in question, it cannot fail to convince every one who reflects on the subject of the truth of the divine origin of both conditions of the light, and also of the operations which were performed by its instrumentality in those widely-different states.

Hitherto whatever had been formed was either inert matter, aeriform masses, liquid fluids, or vegetable existences, none of which possessed the power of volition or locomotion, properly so called. But before the Creator proceeded to embody those free-moving creatures which were to roam in the ocean, inhabit the land, or to fly in the air, there appears to have been some constraining reason, having its origin in the relation of their movements to the surrounding media which demanded that the quantity of light should be equable and regulated; *and that it should henceforth issue* FROM *the same point* TO *which the principle of attraction propends.*

It is not intended to lead the reader into the depths of an enquiry,

* See the *second* Theorem.

having for its object even a surmise in what that mysterious necessity consists. But a brief and comprehensive review of the leading features which characterize the operations of the three days we have so long been engaged in contemplating, will not only go some way towards elucidating this new principle, but likewise will show how intimately connected were these works with the introduction of the light into the material universe, and the rotation of the earth around its axis: the main tenets and fundamental doctrines of the Dynamical Theory.

The first day of the Mosaic week was dedicated to the formation of the light itself, that is, the ethereal fluid and its subsequent division from the darkness; whose immediate consequence, as concerns this world, was the rotation of our sphere on its axis, producing in turn those innumerable geological and geographical developments, which everywhere characterize the earth's surface.

A proper degree of attention bestowed upon what is said to have been the operations of the two succeeding days, will enable us to discover, to entire satisfaction, that light, the rotation of the earth, and the consequences arising therefrom, were mainly influential in effecting, *under* the direction of the Creator, the wonders of these two—the second and third days. For, on looking into the details of the *second* day, it will be observed, that it was the principle of expansion proceeding from the light, which insinuating itself among the waters and combining with their elements or associates, caused them to assume the elasticity and volume requisite to form the atmosphere; while it was to the centrifugal impetus, occasioned by the diurnal motion of the earth, that the elevation of the continents aud the depression of the oceanic hollows are due; and which, in turn, threw the body of waters into a favourable condition for being united with the expansive principle, and being, in part, transformed into the gaseous elements of the atmosphere.

Again, on the *third* day, it was this newly-formed aerial body which was chiefly instrumental in separating the water from its earthy, saline, and acidulous ingredients; and in raising it off the the lands, whereby a separation between the two component parts of the *terraqueous* surface was effected, and each rendered the fitting habitation of the various kinds of plants and animals, with which they were respectively to be tenanted. While, towards the close of the same day, it was light; and the presence of the atmosphere with its watery vapour and gaseous associates and ingredients, which enabled the earth to obey the mandate of the Omnipotent, and to produce the phanogamous orders of herbs and trees with which its surface is now so beautifully variegated and adorned.

And thus we are made to perceive, in the most convincing manner, that all the stupendous transactions of these three primary days may be traced *to the introduction into the creation of indefinite quantities of the principle of expansion proceeding from light on the first*

*day;** while it must appear a self-obvious truth, that these supplies could neither have been of the same nature, nor dispensed in the same quantities as *now* received from the sun; and therefore must have anteceded its final fixation around the central orb of our system. The contemplation of which event, and the results proceeding from it, will form the subject of the next section.

Meanwhile, the general impression left upon the mind, by the perusal of what has been written, necessarily is, that the whole of these operations are linked together in the most intimate manner; and so far, apparently under the necessity of a fixed order in the mode of their arrangement, as to require that the unfolding of the one part should precede the unfolding of the other, while itself depended upon the unfolding of one still more antecedent, like the unrolling of some vast plan admirably delineated by consummate wisdom and skill, where all the separate parts and detached groups are made to harmonize with each other, and to form one grand whole of the most perfect symmetry! of which the boldest and truest conception we can imagine, is, *that they constitute the material results of the degrees of God:*—the materializing of that which had been devised from all eternity, and whose execution required the INSTITUTION *of an* ORDER *of* CAUSES; productive of consequences whose invariable repetition have acquired for them the term of NATURAL EFFECTS. While the causes, themselves, thus emanating directly from the Omnipotent, compose NATURE'S CONSTITUTIONAL CODE, whose contravention cannot, under any circumstances, be attempted with impunity.

* The expressions here used are designed merely as *indefinite*, in contradistinction to the *measured* supplies now received from the sun.

SECTION VIII.

CONCENTRATION OF THE LIGHT AROUND THE SUN; AND COMPLETION OF THE WORK OF CREATION.

CHAPTER XXXVI.

The promise resumed to prove, that during the first three days of the Mosaic week the Light was not concentrated around the Sun. Primitive state of the Light and supposed Centre. Analogical authority, deduced from Astronomy, for assuming, that primarily the Light had a different nature from that which it now has. Evidence to this effect, and that it was precisely similar in kind, though differing in degree, with the force which occasioned the orbital motion of the spheres. The sun, together with all the planets, caused to rotate around their respective axis by means of the primary light. Astronomical proof of the sun's rotation. Dynamical law, that equal but opposing forces produce equilibrium. Astronomical evidence that equal amounts of heat and light are received by the earth from the sun in passing over equal angles round it. These two bodies of evidence prove, that the Light, as now constituted, could *not* have caused either the sun or the earth to rotate. The same conclusion deduced from the *direction* in which the light is now received from the solar centre.

In a previous part of this work a promise was given to prove, that wherever the light was, or whatever was its intimate nature during the first three days of the Mosaic week, *it was not situated—it had not its centre—in or around the sun as it has at present;* on the assumption that had it been so placed it could *not*, in accordance with laws then existing, have accomplished what it did perform, under supreme direction, during that period. I now purpose, if possible, to redeem the pledge then given, while every consideration is earnestly solicited in consequence of the difficulty of the undertaking; and the abstract nature of the reasoning which, alone, can be employed.

To convince the reader that no unwarrantable, or at least no *unprecedented* liberty is taken with their credulity, in supposing a centre or centres of impulse which no longer exist; and at the same time, to exonerate myself from the charge of recurring unnecessarily to final causes, I have to plead the example of astronomers, a class of men who dedicate themselves to the cultivation of a science

which, of all others, possesses the best-founded pretensions to the character of *exact*. In testimony of this I adduce the fact contained in the second clause of the first part of the *fifth* Theorem, namely, "*That the planets move in orbits cutting the ecliptic at different degrees of obliquity;*" and shall bring forward the evidence of Professor Whewell on that point, who, when treating of the stability of the solar system, makes use of the following expressions:—

"They (the planets) might have had any inclination to the ecliptic from no degrees to ninety degrees. Mercury, which deviates most widely, is inclined 7⅔ degrees, Venus 3¾, Saturn 2½, Jupiter 1⅓, and Mars 2. How comes it that their motions are thus contained within such a narrow strip of the sky?"*

In continuation, reference is made to the *fourth* Theorem: "*That the orbital revolutions of the* EARTH *and other planets around the sun, almost in the plane of its equator, and of the satellites around their primaries, are caused by the combination of the sun and the planets' mutual attraction, and an original projectile impulse. . . . . . And that the same laws maintain the comets in their more elliptical orbits, their eccentricity depending wholly on the direction and force of the original impulse which put them in motion.*"

"A planet," observes Mrs. Somerville, "moves in its elliptical orbit with a velocity varying every instant, in consequence of two forces, one tending to the centre of the sun, and the other in the direction of a tangent to its orbit, arising from the primitive impulse given at the time when it was launched into space. . . . . .

"On account of the reciprocal action of matter, the stability of the system depends upon the intensity of the primitive momentum of the planets, and the ratio of their masses to that of the sun; for the nature of the conic sections in which the celestial bodies move, depends upon the velocity with which they were first propelled in space. Had that velocity been such as to make the planets move in orbits of unstable equilibrium, their mutual attractions might have changed them into parabolas, or even hyperbolas, so that the earth and planets might, ages ago, have been sweeping far from our sun through the abyss of space. But as the orbits differ very little from circles, the momentum of the planets, when projected, must have been exactly sufficient to ensure the permanency and stability of the system. . . . . . The magnitude of the sun's mass is the principal cause of that stability. There is not in the physical world a more splendid example of the adaptation of means to the accomplishment of an end, than is exhibited in the nice adjustment of these forces, at once the cause of the variety and of the order of nature."†

In the Treatise on Mechanics, in the Cabinet Cyclopædia, after some clear, preliminary explanations on the nature "*of the motion of bodies on inclined planes and curves,*" we are told—

"The consideration of centrifugal force proves, that if a body be observed to move in a curvilinear path, some efficient cause must exist which prevents

* Bridgewater Treatise, pp. 165, 166.
† Connexion of the Sciences, pp. 5—16.

it from flying off, and which compels it to revolve round the centre. If the body be connected with the centre by a thread, cord, or rod, then the effect of the centrifugal force is to give tension to the thread, cord, or rod. . . . . . But if a body be observed to move in a curve without any visible material connexion with its centre, as is the case with the motions of the planets round the sun, and the satellites round the planets, it is usual to assign the cause to the attraction of the body which occupies the centre; in the present instance the sun is that body, and it is customary to say, that the *attraction* of the sun, neutralizing the effects of the centrifugal force of the planets, *retains them* in their orbits. We have, elsewhere, animadverted on the inaccurate and unphilosophical style of this phraseology, in which terms are admitted which intimate not only an unknown cause, but assign its seat, and intimate something of its nature. All that we are entitled to declare in this case is, that a motion is continually impressed upon the planet; that this motion is directed towards the sun; that it counteracts the centrifugal force; but from whence this motion proceeds, whether it be a virtue resident in the sun, or a property of the medium or space in which both sun and planets are placed, or whatever other influence may be its proximate cause, we are altogether ignorant."*

"The reader," says Sir John Herschel, "has now been made acquainted with the chief phenomena of the motions of the earth in its orbit round the sun, and of the moon about the earth. We come next to speak of the physical cause which maintains and perpetuates these motions, and causes the massive bodies so revolving to deviate continually from the directions they would naturally seek to follow, in pursuance of the first law of motion (see Mechanics, in Cabinet Cyclopædia, chap. iii.), and bend their courses into curves concave to their centres. . . . . .

"Is it not reasonable to imagine," he asks, a little further on, "that the force of gravity *may* extend so far as 60 radii of the earth, or to the moon? and may not this be the power—for *some* power there *must* be—which deflects *her* at every instant from the tangent of her orbit, and retains her in the elliptic path which experience teaches us she actually pursues?

"Suppose a string to connect the earth's centre with a weight at its surface, whose strength should be just sufficient to sustain that weight suspended from it; let us, at the same time, for a moment, imagine gravity to have no existence, and that the weight is made to revolve with the *limiting velocity* which that string can hardly counteract; then will its tension be just equal to the weight of the revolving body; and any power which should continually urge the body towards the centre, with a force equal to its weight, would perform the office, and might supply the place of the string, if divided. Divide it, then, and let gravity act in its place, and the body will circulate as before; its tendency to the centre, or its *weight*, being just balanced by its centrifugal force. Knowing the radius of the earth, we can calculate the periodical time in which a body so balanced must circulate to keep it up; and this appears to be 1h. 23m. 22s."

This accomplished astronomer then shows, by a succint but lucid chain of reasoning, which I am sorry the limits of this work do not admit of being transcribed, that the application of this rate, and its striking nonconformity with the observed orbital period of the

* Mechanics, in Cab. Cyc. chap. viii. pp. 99—102.

moon, necessarily constrain astronomers to assume, that the force of gravitation decreases at a ratio directly proportioned to the square of the intermediate distance; and that thus corrected, the rate above obtained yields the precise duration of the moon's orbital path around the earth.

And, in continuation, after making it manifest that the same reasoning, when applied to the case of the earth's revolution around the sun, accounts also satisfactorily for it, he enters upon the point which more immediately concerns us, by observing—

"Now, the moment we come to numbers, an obvious incongruity strikes us. When we calculate, as above, from the known distance of the sun, and from the period in which the earth circulates about it, what must be the centrifugal force of the latter, by which the sun's attraction is balanced (and which, therefore, becomes an exact measure of the sun's attractive energy, as exerted on the earth), we find it to be immensely greater than would suffice to counteract the *earth's* attraction on an equal body at that distance, greater in the high proportion of 354,936 to 1. It is clear, then, that if the earth be retained in its orbit about the sun by *solar attraction*, conformable in its rate of diminution with the general law, the force must be no less than 354,936 times more intense than what the earth would be capable of exerting, *cæteris paribus*, at an equal distance.

"What, then, are we to understand from this result? Simply this—that the sun attracts as a collection of 354,936 earths occupying its place would do; or, in other words, that the sun contains 354,936 times the mass or quantity of ponderable matter that the earth consists of."*

The design in adducing these evidences, was to show, that in assuming an original direction for the primary light, which it, now, no longer possesses, I did not overstep the assumptions made in the exact science of astronomy, and this has been completely, though somewhat embarrassingly exemplified by the fact, that when the CENTRIFUGAL FORCE—the origin and somewhat of the nature of which it was desired to elucidate—is mentioned, it seems to be either inferred, implied, or merely assumed, *as a force which must unavoidably exist*, in order to complete the laws which govern planetary motion. A remarkable feature in the writings of astronomers; who, otherwise, are so justly celebrated for the depth and extent of their acquirements, for the keenness of their scientific acumen, and for the scrupulous exactness of all their manipulations, and which assuredly warrants the taking up the position now intended to occupy.

It will have been observed, that where there was sought a knowledge of the primary projectile impulse, or, as Mrs. Somerville expresses it, "the primitive momentum of the planets," there have been offered definitions—of the most lucid description, no doubt—of the laws of CENTRIPETAL ATTRACTION; those of CENTRIFUGAL FORCE being merely so far explained as a reference to those given

* Astronomy, Cab. Cyc. chap. vii.

in mechanical writers would admit of; while, strange to say, the writers referred to disclaim all knowledge of the intimate nature of even the countervailing force, ATTRACTION, supposed to be the better known of the two, and more immediately under cognizance, as deduced from the attraction of bodies on the earth's surface.

Nevertheless, what has now been said, and the perusal of those quotations will be sufficient to convince the most scrupulous, that in a science such as astronomy, every result of which is the fruit of the most rigorous mathematical demonstration, its professors considered themselves warranted in having recourse to the doctrine of an "original projectile impulse given when the bodies were launched in space;" the force and direction of which, differing for each planet and comet, can only be estimated relatively, or by the amount of the gravitation to which it is an equipoise; while it is clearly admitted that the motion in space is quite independent of that of rotation. Such being the case, there is certainly no reason why I should be denied a similar privilege of supposing that the rotatory impulse produced by the formation of the light and its division from the darkness, originated from such a condition of the light as should be most conducive for impressing on the planets of our system those various degrees of obliquity of axis to the planes of their respective orbits, which astronomy announces they actually possess; when no one denies to the professors of that science the kindred assumption which they have embodied in their calculations, to account for the various rates of velocity of the planets and comets in their respective orbits, and the degrees of obliquity with which those orbits cut the plane of the ecliptic.

It is precisely with a view to assume this privilege that the quotations now perused have been given; for, by the first part of the *fifth* Theorem, it will be seen, "*That the* EARTH *and other planets have their axes inclined at various degrees of obliquity to the planes of their respective orbits.*" The authorities which support this well-known astronomical truth may be consulted if desired, while I apply to it one of the facts elicited during the course of those investigations, namely, that the introduction of the light into the material universe, and its subsequent division from the darkness, were the immediate causes of the spheres revolving around their respective axis; from which it follows, as a direct consequence—similar to that of the assumed primary projectile impulse—*that the impulses communicated, were precisely those whereby—according to the nature of the light then introduced—these different degrees of obliquity of axes, with respect to the planes of their orbits could have been given to the planets of our system.*

This conclusion receives confirmation from the assumption, that the various degrees of obliquity, in the orbital motions of the planets, with respect to the plane of the ecliptic, proceeded from precisely the same principle and originated from causes of a similar

kind with those which occasioned the differing degrees of obliquity of their axes to the planes of these orbits, the only dissimilarity being *the extent of the revolution performed;* for there must be considered an axis round which the revolution is described as really in the one case as in the other, although the points of their existence in space differ so far, that the former is imagined to be in the centre of gravity of its periodical path, and, consequently, exterior to the mass of the planet, while the other passes through the centre of the revolving body itself. Still it is maintained, that they each spring from a cause, which, although put into activity at widely divergent periods, is identically the same.

Having removed this preliminary difficulty, I shall continue the scope of the argument designed to form the chief subject of this section, by expressing my belief, that in a former part of this treatise it has been satisfactorily proved *that the formation of the light and its division from the darkness, caused the earth to revolve around its axis.* Indeed, so long as there exists a single peak of granite perforating the strata, and pointing its rugged apex to the clouds, this truth may be considered irrefragable, and capable of supporting any chain of reasoning which may be raised upon it. Indeed, the geological evidences are very conclusive. And, as long as this theory stands, it supports the assumption of the non-rotation of the earth during the whole period required to produce these geological manifestations. And just as gravitation, ascertained on the earth's surface, where it is within the reach of actual computation, is made the standard to determine the full power of that all-pervading force, whose comprehensive grasp assists to control the material universe; so should the power which tore up and dislocated the earth's mineral crust, when the globe was first made to rotate around its axis, be employed as a guage to determine, much more approximately than is known at present, the mighty energy of that projectile force which was made use of, by the Creator, at the beginning, to overcome the entire inertia of the spheres themselves, when they were translated in space, and delivered up, for ever afterwards, to the unerring guidance of these justly equipoised but divellent forces, which now together govern their orbital paths.

But the earth, though not impressed with diurnal motion during that period, must have revolved around the *un*illumined sun; and if it revolved around the sun, *the sun must have contained the precise amount of matter which it still possesses;* for any addition of *ponderable matter* made to the great central orb, when it became illuminated, would have destroyed the equilibrium, which the earth and all other planets around the general centre of gravity demand, in order to fulfil the conditions of their permanency.

Unless it can be proved, that the common centre of gravity of the solar system was changed on the sun's becoming illuminated, this conclusion must be correct; and, therefore, to those who do not

admit it, the arduous undertaking devolves of proving upon equally responsible and solid bases, that the common centre of gravity of our system underwent a change on the fourth day of the Mosaic week.

Assuming it, however, to be established, that the earth did *not* rotate previous to the formation of the light and its division from the darkness; and that it did commence its rotatory motion in consequence of those events taking place, the same principle may be applied to all the other spheres of our system; and it may also be concluded with respect to them, *that neither did they rotate previous to the formation of the light;* consequently, all those known to possess that motion, must, like the earth, have acquired it on the formation of the light and its division from the darkness.

The next point to be established is the rotatory motion of the central orb of the system. This is done by referring to the second part of the *fifth* Theorem, which states, "*That the sun, and such of the planets as afford sufficient data for astronomical calculations, are known to have rotatory motion. That of the sun,*" *according to Delambre*, "*being completed in days* 25.01154, *which, although somewhat different from the estimate of others, yet all astronomers agree in that it does revolve around its axis.*"

The following important evidences prove the truth of this assertion:—

"The oblate form of several of the planets," observes Mrs. Somerville, "indicates rotatory motion. This has been confirmed in most cases by tracing spots on their surface, by which their poles and times of rotation have been determined.

"The sun revolves in twenty-five days and ten hours about an axis which is directed towards a point half way between the polar star and Lyra, the plane of rotation being inclined by 7° 30′, or a little more than seven degrees to the plane of the ecliptic; it may, therefore, be concluded that the sun's mass is a speroid, flattened at the poles. From the rotation of the sun, there is every reason to believe that it has a progressive motion in space, although the direction to which it tends is unknown. . . . . .

"The sun and all its attendants rotate from west to east, on axes that remain nearly parallel to themselves in every point of their orbit, and with angular velocities that are sensibly uniform, ... that is, with an equable motion which is never either faster or slower."*

"It is hardly possible," says Sir John Herschel, when treating of the sun, "to avoid associating our conceptions of an object of definite globular figure, and of such enormous dimensions, with some corresponding attribute of massiveness and material solidity. That the sun is not a mere phantom, but a body having its own peculiar structure and economy, our telescopes distinctly inform us. They show us dark spots on its surface, which slowly change their places and forms, and by attending to whose situations, at different times, astronomers have ascertained that the sun revolves about an axis, inclined at a constant angle of 82° 40′ to the plane of the ecliptic,

* Connexion of the Sciences, pp. 75, 438.

performing one rotation in a period of 25 days, and in the same direction with the diurnal rotation of the earth, that is, from west to east. Here, then, we have an analogy with our own globe; the slower and more majestic movement only corresponding with the greater dimensions of the machinery, and impressing us with the prevalence of similar mechanical laws, and of, at least, such a community of nature as the existence of inertia and obedience to force may agree."*

These perspicuous and convincing quotations, from authorities so well calculated to give them importance, are sufficient, without further evidence, to establish the fact of the sun's rotation, and of its similarity of direction and assumed community of origin with the diurnal rotation of the earth.

In continuation, it may be taken for granted, that all will agree with the rudimentary truth stated in the *second* Theorem: "*That the external light and heat received by the earth comes from the sun;*" although, from its being irrelevant to the present purpose, it need not be enquired whether it emanates from the body of that luminary, or, as now more generally believed, from a luminiferous atmosphere which surrounds it. These points will undergo special investigation in their proper places; meanwhile, all that is asked is, what cannot well be denied—*That the external light and heat received by the earth comes from the sun;* and, that it is received by us on whatever side we may happen to be of that central point of our system.†

Neither is it intended, at present, to attach much importance to the argument which might be adduced, were any one hardy enough to undertake it, by supposing that the light which now either surrounds and emanates from the sun, could ever have caused the solid nucleus of that luminary to revolve; because, if the light, by its expansive or repulsive power, that is, *by its tendency to proceed from the centre to the circumference,* be that which caused the bodies of the system to revolve, it would be absurd to suppose, that whatever resides *in* that centre could thereby have had rotatory motion communicated to it so long as the light remained in the state it is in at present. I shall, therefore, proceed to a more certain line of proof. By adducing certain axioms in mechanics, in order that they may exercise their due influence over the truths which have already been established. It is stated in the *seventy-ninth* Theorem:—"*That the power of a force to produce rotation is accurately estimated not by the force alone, but by multiplying the distance of the direction of the force from the axis (called the leverage) by the force itself, the product of which is an important datum in mechanics, and is called the moment of the force around the axis. And, that if the moment or sum of the moments of the forces which tend to turn a body in one direction*

* Astronomy, in Cab. Cyc. chap. v. p. 184, American edition.

† See Meteorology, by Dr. Thomson, Introduction, pp. xix.—xxi. for a concise but clear elucidation of this fact.

be equal to the moment or sum of the moments of forces which tend to turn it in the opposite direction, they will mutually neutralize each other and produce equilibrium."

Although this theorem is essential to the development of the future reasoning, nevertheless, as the principles on which it is founded are undoubted, the data from which it has been constructed will be alone submitted.

"The power of a force," it is stated in the Treatise on Mechanics in the Cabinet Cyclopædia, "to produce motion is, therefore, accurately estimated, not by the force alone, but by the product found by multiplying the force by the distance of its direction from the axis. It is frequently necessary in mechanical science to refer to this power of a force; and, accordingly, the product just mentioned has received a particular denomination. It is called the *moment* of the force around the axis.

"The distance of the direction of a force from the axis is sometimes called the *leverage* of the force. The *moment* of a force is, therefore, found by multiplying the force by its leverage, and the energy of a given force to turn a body round its axis is proportional to the leverage of that force.

"From all that has been observed it may easily be inferred, that if several forces affect a body moveable on its axis, having tendencies to move it in different directions, they will mutually neutralize each other and produce equilibrium; if the sum of the *moments* of these forces which tend to turn the body in one direction be equal to the sum of the *moments* of those which tend to turn it in the opposite direction, these forces will produce equilibrium."*

It must, therefore be obvious to every one, after perusing what has been stated, that as "the external light and heat which are received comes from the sun," and is equally imparted to the earth, whatever be the position it occupies in space with relation to that luminary, those rays must be *disseminated from the sun in all directions,* whether they emanate from the body itself, or from a luminiferous atmosphere which surrounds it. But then it has also been shown, "that equal forces acting in opposite directions, with a tendency to cause rotation, so far from producing that motion, neutralize each other's influence, and produce equilibrium." And as, in the case of the sun—without entering on the question of the influence exercised by rays of light on the body whence they emanate—the same light proceeds from its equatorial region in every direction, these rays must be considered to be equal forces acting in all these directions; and applying the mechanical law above cited to this assumption, there arises the undeniable conclusion, *that the light as it is* NOW *constituted cannot, and, consequently, never could have caused the solid body of the sun to revolve around its axis.* But, on the other hand, having been made aware, that the introduction of the primary material light into the universe occasioned the rotation of all bodies of the system around their respective axis, in which motion the

* Cab. Cyc. vol. v. pp. 135, 136.

central orb participates, the application of this truth to the conclusion come to above, obliges us to consider, that although it was the light which caused the solid nucleus of the sun to rotate around its axis, *it could not have been the light as now situated or as now constituted.*

Indeed, these two states of the light bear a somewhat similar relation to each other, as that which now subsists between the invisible electro-magnetic streams, capable of being made, in the hands of a skilful operator, to produce such wonders in decomposition and composition, and the brilliant radiance which bursts forth from the same currents, when the wires by which they are conducted are charcoal tipped, and made to collapse upon each other. They now illumine and dazzle by their visible splendour; they powerfully affect the eye, but they no longer produce, hiddenly, those almost miraculous changes on other bodies which they did before, when passing along silently and unseen by means of their conductors. And so with the primary light, during the first three days of its existence, before it was made to converge around the sun, ere yet there was an atmosphere, its conductor, and before the sea and the land were separated from each other, it was wholly invisible, and wonder working.

This forms the first of a continued series of proofs which I intend to bring forward to demonstrate, that the primary light did not reside in or around the sun during the first three days of the Mosaic week; but that on the fourth day, when God set the light in the firmament of heaven, he made the two great fountenal streams of electricity to meet around the sun, the central orb, and so to dispense light to all its attendant orbs.

The next proof to be adduced is somewhat similar to the preceding, namely—that had the light, from the first, been situated in its present centre, it could not have caused the *earth* to revolve around its axis. To substantiate this, let it be considered established, that our planet has rotatory motion; that it was impressed upon it by the expansive principle of the primary light; and that the sun's rays, proceeding in straight lines, strike the earth perpendicular to its surface, and consequently to its axis; and, then, let us become acquainted with what is contained in part of the *eightieth* Theorem —"*That if the force applied to a body be directed upon the axis and at right angles to it, no rotatory motion will be produced.*" And again, "*If a sphere at rest in space receive an impulse passing through its centre of gravity, all its parts will move with an equal velocity in a* STRAIGHT LINE."

Combining these truths with what has been admitted above, the following self-obvious conclusion must be the result:—

That as the rays of sun-light (supposed, for a moment, to have been the impelling power) affect the earth in lines perpendicular to its centre of gravity, they could not, according to the mechanical axiom

just cited, have caused the earth to revolve around its axis, *so long as they impinged upon it in that direction*. But, as it has been admitted, that the earth does revolve, and that the introduction of the primary light into our system was the immediate secondary cause thereof, it is therefore necessary, as in the preceding case, to look to some other relative position of the primary light with respect to the earth, and *some other state of it*, as the cause of the rotation of this latter body. *It was not the light as at present constituted, but it was the light; therefore it must have been the light from some other centre, and consequently in some other condition.*

Another corroborating proof can be drawn from nearly the same source, namely, what is termed *the obliquity of the ecliptic;* the plane of the latter, or apparent path of the sun, being at present intersected by that of the *equator* at an angle of 23° 28′. For it has been considered by astronomers, that the longer axis of the elliptic orbit of the earth around the sun, coincided with the autumnal equinox about the period of the formation of the light; and it being admitted that the light proceeds in straight lines from its centre, had it then flowed from the sun, it must have proceeded in lines parallel to the plane of the ecliptic; and, consequently, would have come into contact with the earth in such a direction as would have caused it (if it could have produced rotation at all under such circumstances) to have revolved with its axis perpendicular to that plane or to the *ecliptic*, and not as it actually does, in lines perpendicular to the plane of the *equator*, which at present is 23° 28′ distant from the other, and formerly was somewhat more oblique; because this would be to admit the absurd conclusion, that the light could have acted in planes where it did not exist; or, what is the same thing, out of the plane where it was supposed to have been, if it be imagined to have been centred at that time around the sun. But as it has been shown by sufficient proof, that the primary light was actually the propelling power, whilst astronomy announces that the obliquity of the plane of the equator to that of the ecliptic, at the period I allude to, was nearly 24°, we are compelled, as in the preceding cases, to look to some other relative positions of the light with respect to the earth, and also to some other state of it for the explanation of the phenomenon in question; while the elaborate proofs and investigations already gone through, demonstrate to a certainly, *that as far as regards the* DIRECTION OF THE IMPELLING POWER, *the primary light which caused the earth to revolve, did not come from the solar centre of our system.*

SECTION VIII.

CONCENTRATION OF THE LIGHT AROUND THE SUN; AND THE COMPLETION OF THE WORK OF CREATION.

CHAPTER XXXVII.

Continuation of the argument commenced in the foregoing chapter. The non-concentration of the Light, during the first three days of the Mosaic week, deduced from the measured quantity of light and heat received at present from the sun. Astronomical evidences. Confirmatory conclusion come to from these facts. The same deduction drawn from the circumstance, that the act of illuminating the Sun caused it to become the teller of the earth's signs, seasons, days, and years. Contemplation of the magnitude of the achievement whereby the expansive principle was permanently fixed in the centre of our system. Corroborative conclusion from the peculiar direction in which the primary light acted, in order to occasion the rotation of the earth; and presumptive evidence of its being akin to electro-magnetism.

Having been thus made aware, in the preceding chapter, by arguments deduced, from the *direction* in which the light now flows to the earth, that it could not have caused it to rotate had it, when first formed, been concentrated around the sun, it is intended in the present division to pursue a distinct line of evidence in favour of the same argument, by proofs arising from the *quantity* of light at present imparted daily by the sun to the earth. With this design it is necessary to become acquainted with the truths contained in the *second* Theorem, which states, "*That the earth is a non-luminous body, receiving its external light and heat from the sun. And that the heat received is a fixed quantity, subject to the following invariable law, namely, 'that the momentary supply varies in the exact proportion of the angular velocity, i. e., of the momentary increase of longitude;' from which it follows, that equal amounts of heat are received from the sun in passing over equal angles round it, in whatever part of the ellipse these angles may be situated.*" The latter clause of this theorem, which is rather abstruse in itself, exercises so important an influence over the reasoning in this particular line of proof, that it is considered essential to open it up a little to the general reader.

Mrs. Somerville explains this astronomical law in the following perspicuous manner :—

"A planet moves in its elliptical orbit with a velocity varying every instant, in consequence of two forces, one tending to the centre of the sun, and the other in the direction of a tangent to its orbit, arising from the primitive impulse given at the time when it was launched into space. Should the force in the tangent cease, the planet would fall to the sun by its gravity. Were the sun not to attract it, the planet would fly off in the tangent. Thus, when the planet is at the point of its orbit farthest from the sun, his action overcomes the planet's velocity, and brings it towards him with such an accelerated motion, that, at last, it overcomes the sun's attraction, and, shooting past him, gradually decreases in velocity until it arrives at the most distant point, where the sun's attraction again prevails. In this motion the *radii vectores*, or imaginary lines joining the centres of the sun and the planets, pass over equal areas or spaces in equal times." . . . .

And a little further on, when rebutting the erroneous ascription of the cause of apparent increase of temperature of the northern hemisphere, assumed from the comparative size of its fossil flora, she thus expresses herself—

"This change of temperature has been erroneously ascribed to an excess in the duration of spring and summer in the northern hemisphere, in consequence of the eccentricity of the solar ellipse. The length of the seasons varies with the position of the perihelion of the earth's orbit, for two reasons. On account of the eccentricity, small as it is, any line passing through the centre of the sun divides the terrestrial ellipse into two unequal parts, and, by the laws of elliptical motion, the earth moves through these two portions with unequal velocities. The perihelion always lies in the smaller portion, and there the earth's motion is the most rapid. In the present position of the perihelion, spring and summer, north of the equator, exceeds by about eight days the duration of the same seasons south of it. Yet Sir John Herschel has shown, that by this alternation neither hemisphere acquires any excess of light or heat above the other; for although the earth is nearer to the sun, while moving through that part of its orbit in which the perihelion lies, than in the other part, and consequently receives a greater quantity of light and heat; yet, as it moves faster, it is exposed to the heat for a shorter time. In the other part of the orbit, on the contrary, the earth being further from the sun, receives fewer of his rays, but because its motion is slower it is exposed to them for a longer time. And, as in both cases the quantity of heat and the angular velocity vary exactly in the same proportion, a perfect compensation takes place. So that the eccentricity of the earth's orbit has little or no effect on the temperature corresponding to the difference of the seasons."*

Sir John Herschel's explanation of the same uranographical phenomena, though equally perspicuous, proceeds by a different line of argument, and will, on that account, be rendered more interesting and instructive.

"It has been shown," he says, "that the *apparent* path of the sun is a

* Connexion of the Sciences, pp. 9, 85, 86.

great circle of the sphere, which it performs in the period of one sidereal year. From this it follows, that the line joining the earth and sun lies constantly *in one plane;* and that, therefore, whatever be the *real* motion from which this *apparent* motion arises, it must be confined to one plane, which is called the *plane of the ecliptic.* . . . . .

"The real orbit of the sun, as referred to the earth supposed at rest, is not a circle with the earth in the centre. The situation of the earth within it is *eccentric, the eccentricity* amounting to 0.01679 of the mean distance, which may be regarded as our unit of measure in this enquiry. . . . . .

"This elliptic form of the sun's path, the eccentric position of the earth within it, and the unequal speed with which it is actually traversed by the sun itself, all tend to render the calculation of its longitude from theory difficult, and indeed impossible, so long as the law of its actual velocity continues unknown. This *law* is not immediately apparent. It was not, therefore, without much painful and laborious calculation, that it was discovered by Kepler, and announced in the following terms:—'Let a line be always supposed to connect the sun, supposed in motion, with the earth, supposed at rest; then, as the sun moves along its ellipse, this line (which is called by astronomers *the radius vector) will describe* or *sweep over that portion of the whole area or surface* of the ellipse which is included between its consecutive positions; and the motion of the sun will be such *that equal areas are thus swept over* by the revolving radius vector *in equal times,* in whatever part of the circumference of the ellipse the sun is moving.' . . . .

"The circumstances of the sun's apparent annual motion may, therefore, be summed up as follows:—It is performed in an orbit lying in one plane passing through the earth's centre, called the plane of the ecliptic, and whose projection on the heavens is the great circle so called. In this plane, however, the actual path is not circular, but elliptical; having the earth, not in its centre, but in one focus, the eccentricity of this ellipse is 0.01679, in parts of a unit equal to the *mean distance,* or *half the longer diameter of the ellipse;* and the motion of the sun in its circumference is so regulated, that equal areas of the ellipse are passed over by the radius vector in equal times."*

As a direct sequitur from these premises, and from the attendant circumstance of the sun dispensing, at all periods, a constantly equal degree of light and heat, it follows—that as the radii vectores sweep over areas proportional to the times, the light and heat received by the earth must, likewise, be equal and proportional to the times.

According, therefore, to these unanimous and conclusive authorities, there can be no doubt that the sun dispenses only *a limited daily quantum of light and heat,* whose amount being known, and being subjected to examination, can be exactly appreciated; and that this fact stands on bases sufficiently firm to support whatever superstructure it may be considered expedient to raise upon it.

This treatise has chiefly been directed to prove that during the *second* day of the Mosaic week, sufficient light was present wherewith to form the whole aerial body of the atmosphere, and also to supply it with its constituent amount of aqueous vapour. That, during

* Astronomy, Cab. Cyc., American edition, pp. 176—180.

the first part of the *third* day, there was sufficient light to separate the waters from the dry land, by means of the newly-formed atmosphere; and, during the succeeding portion of that day, to form and complete the two principal classes of plants comprising the *phanogamous* division of the vegetable kingdom. And, when these facts are contemplated with relation to the *limited* supply of light which is *now* received, it must be admitted that the light, as it is now constituted, could not, during the circumscribed periods of time above mentioned, form an atmosphere, separate the aqueous from the solid part of a sphere, and produce fully two-thirds of a vegetable kingdom, from their germ to full fruition; and *that when the light did perform these works, it was not then, as it now is, concentrated around the central orb of our system, to dispense a measured supply of light and heat for the purpose of sustaining and invigorating the wonderful fabric which had been produced by its instrumentality when differently situated, and directed by the wisdom and the strength of the Omnipotent;* while the presence of these works show, evidently, that the light actually did exist. This conclusion will be the more readily acquiesced in, when it is recollected, that it is in strict accordance with the words of inspiration; and will, in the sequel, lead to full and concurring views of the stupendous works of the Creator, who, alone, could wield the movements of that potent principle, and cause it first to operate in the manner alluded to, and afterwards to place it wherever most conducive for his designs, and the well-being of his creatures.*

It is, therefore, one of the clearest and best-established deductions which can be drawn from the Dynamical Theory, that the light did *not* during the first three days of the Mosaic week, occupy the place it now does in the centre of our system; and that, too, for the concurring reasons which have been given, namely—*that if so situated it could not have done what it actually has performed.*

It is when contemplating the primary light as existing in altogether another state or condition during the brief period alluded to, that the most invigorating views of the declarations of Scripture are obtained. For the subject under consideration has assumed a position from which neither human knowledge nor all the treasures of science can extricate it. These have, indeed, furnished the means of accomplishing what has already been done, and what will here-

* As the earth revolved around the sun, *long before the period of the Mosaic week*, had the light been concentrated around the sun the moment this latter was willed into existence, it would necessarily have served for signs, seasons, days, and years, *from that moment;* as, in place of the earth revolving around an opaque body, it would have been revolving round an *illuminated* one. This, however, is not in accordance with the language employed in Genesis; for no mention is made in it of these "signs, seasons, days, and years," until the fourth day of the Mosaic week, when it is expressly stated, that the sun was illuminated by the light being concentrated around it, or "set in the firmament of the heaven;" and from that period these seasons, measured out by the rays of the luminaries, then commenced.

after be brought forward to prove, that the primary light did *not* occupy the centre of the solar system during the first three days of the Mosaic week; but as it cannot be doubted, without calling into question the evidence of our senses, that it does so *now*, science has yet to inform the world of the resources which it possesses, for explaining *how the mighty change of centre was achieved; how that which, within the consecutive periods of three natural days, could cause a world to revolve, form an atmosphere, and the greater part of a vegetable kingdom, was changed in character, and compressed around a centre.* No offence is intended to science, and few, perhaps, more heartily admire its powers, or wonder at its innumerable records, than I do; nevertheless the truth must be manfully and unequivocally proclaimed. SCIENCE, *in all the range of its resources, knows no power capable of changing the body of light, which enlightens our system, from any other condition in space to that which it now has, and of compressing it around the centre which it now occupies.* It is here utterly helpless, and consequently must gladly cling to any means which may be found to extricate it from such a dilemma.

Nor is any disparagement offered to science by having, in this instance, made allusion to final causes. It could not be avoided, unless this part of the discourse had been left unfinished. For, with all that predilection which I entertain for the scientific division of the evidences, *its proof was carried to the very extremity of materialism;* by its assistance matter was traced until it almost vanished, and became so tenuous as scarcely to be appreciable by the senses; but even when this was reached, when on the very verge of materialism, we were reminded by science, that being still within the bounds of matter and the domains of gravity, the stern and unbending law of inertia forbade us to believe, that "spontaneous motion could by any means be engendered in it;" from the resources within her reach all further hope of assistance was in vain; and that the origin of motion of the ethereal fluid must be sought for where attraction has no power, LIGHT and HEAT having been removed from under its dominion.*

Neither, perhaps, should it be undertaken to prove, that there was, on its first formation and division from the darkness, an irresistible rush of LIGHT, akin to that of the waters, when those of the primitive ocean, on being made to revolve, swept onwards from the respective poles to find their level of rotation; or like to the atmospheric elements, when the firmament stretched itself throughout the expanse of its destined space; although strict analogy, and the mighty labours which the light had to perform on the first day of the Mosaic week, lead to the supposition that such was really the case; but of this there is no *direct* testimony, and, therefore, I shall approach this part of the subject indirectly, or by the differential method; trusting, by that means, to make manifest the irresistible

* *Forty-sixth* Theorem.

influence which the primary light put forth, by the effects which it has produced; the stupendous works, then accomplished by its instrumentality, which still remain to exhibit the undeniable monuments of its amazing power.

Before proceeding to make good this point by an indirect approach, it may be well to recapitulate once more the expression of the equipoising forces which restrain the earth in its orbital path around the sun. These constitute the subject of the *fourth* Theorem, which states, "*That the orbital revolutions of the earth and other planets around the sun, almost in the plane of its equator, and of the satellites around their primaries, are caused by the combination of the sun and the planets' mutual attraction, and an original projectile impulse; whilst the whole system is connected and regulated by the law of the squares of their periodical times being proportional to the cubes of their mean distances from the sun. That the same laws maintain the comets in their more elliptical orbits, their eccentricity depending wholly on the direction and force of the original impulse which put them in motion.*"

And in continuation, the words of the *third* Theorem, in consequence of their direct bearing on the present argument:—"*That the Earth has a double movement in space; one by which it revolves around its own axis in* 24 *hours solar time, or in* 23 *hours* 56′ 4.09″ *sidereal time, and another movement whereby it performs its periodical revolution, in an invariable plane, around the sun, in what is termed the tropical year, of* 365 *days* 5 *hours* 48′ 49″·7. *That these two motions are entirely independent of each other. And that if the Earth did receive its double movement from a single impulse, it is considered, by computation, that the impulse must have passed through a point about twenty-five miles from its centre.*"

The application of the Dynamical Theory to these astronomical data, and the blending of some of their best established announcements with the conclusions which have been come to during the course of these investigations, lead to two distinct but equally important results.

With respect to the *direction* in which it is apprehended the primary projectile impulse was impressed upon the earth, it will be obvious that if this did not *simultaneously* cause the earth's motion in space, and its rotation around its axis; but, that the former preceded the latter *in time* by the whole period necessary for the deposition of the principal portion of the strata; then, the force which caused the earth and other planets to revolve around the sun, and all around their common centre of gravity, must have been of a description which (in connexion with the other existing laws of matter) would cause them to revolve around each other, and all around the common centre alluded to, *without* rotating around *their individual axis*. The deduction itself is so necessarily evident as scarcely to require either explanation or comment; but the *direction* of the impelling force is by no means so easily determined; never-

theless I am inclined to consider it to have been akin to that power which, ages afterwards, caused the orbitally revolving earth to rotate around its axis, without affecting the forces which maintained it in its predetermined path through the heavens, and which, no doubt, impressed similar motion on the other primary bodies of the system around their respective axis.

Regarding the *diurnal motion*, which this theory has all along maintained was *not* communicated to the earth coevally with its orbital impetus, otherwise the geological phenomena which bestrew its surface could not have been satisfactorily accounted for, I shall now have to go more into detail, in order to substantiate, by astronomical data, the position which other natural evidences occasioned me to assume, and, hitherto, have enabled me to maintain.

Attraction, one of those counterpoising forces which retain the earth in its orbital revolution around the sun, is (as has already been quoted) thus described by Sir John Herschel—

"The direction of attraction at any point of the orbit of each planet, *always passes through the sun*. No matter from what ultimate cause the power which is called gravitation originates, be it a virtue lodged in the sun as its receptacle, or be it pressure from without, or the resultant of many pressures or solicitations of unknown fluids, magnetic or electric ethers, or impulses; still, when finally brought under contemplation, and summed up into a single resultant energy, its *direction* is from every point on all sides towards the sun's centre."

Being made aware that such is the direction of one of the divellent forces which, acting on the earth in motion in the heavens, retains it in its destined orbital path; and bearing in mind the deliberate conclusion previously come to—"*that these two motions are quite independent of each other*," inasmuch as *that there was duration in time, between orbital revolution in space and diurnal rotatory motion, sufficient to admit of the deposition of the greater part of the stratified formation of the earth's outer crust;* we necessarily arrive at the same conclusion as before, namely, that the other divellent force which is required to maintain the earth and other spheres in their orbits, must have been communicated at right angles, or tangentially, to that which is occasioned by the centripetal force of gravity, and so have caused the resultant direction in which the spheres travel in space.

This conclusion is most interesting, inasmuch as it points out, in language which can neither be set aside nor misunderstood, that the force which acted at right angles to the direction of gravity, and by overcoming its aggregate inertia caused the earth ever to be disposed, but, owing to the perfect equipoise, never able to fly off at a tangent from its path in space, must have been similar to that which is assumed to have emanated from the primary light, when introduced into the material universe, and divided from the darkness, on the FIRST day of the Mosaic week; because the result of

this last was also to communicate motion in a direction tangentially to the molecular attraction passing through the earth's centre, and to overcome the inertia of its recumbent matter. It was not, however, merely to reach this conclusion, notwithstanding its importance, that at present the attention is pointed to these facts. I more particularly desire the mind to be directed to the circumstance itself, of the *just equipoise of the two divellent forces*, and to the knowledge, that to this we are indebted for the steadiness and certainty with which the earth performs its annual revolution around the sun; consequently, any increase or decrease of either of those counterbalancing forces would be destructive of that security; would, in reality, disturb the whole economy of the solar system.

Now it is, when this conviction is strongly impressed upon the mind, that we recognise, most clearly, the importance of the conclusions previously come to, namely—that there was a protracted period during which the earth did *not* rotate around its axis; but had *diurnal* motion impressed upon it, in common with the other spheres of the system, at a comparatively recent period; and that thereby such a centrifugal impetus was communicated to the earth as to raise its continental ridges and mountain chains, to depress the oceanic hollows, and to occasion the previously circumfluent water, in rushing from the poles, to retire within these receptacles: because, as it has already been observed, if neither of the forces which restrained the earth in its orbital path could, without suffering disturbance, admit of either increase or of decrease, then are we constrained to conclude, that the force which caused the orbital revolving earth to rotate diurnally, could not have impinged upon it, equipoised as it was, either in the direction of gravity, or in that of its divellent counterbalancing force; and if it could not have impinged upon it in either of these two directions, neither could it have done so in any intermediate one; because this, too, would have tended, as far as it went, to have augmented one of the equipoising powers, to the certain overthrow of the other.

This wholly excludes the assumption, that the force which caused the earth to revolve around its axis impinged upon it in the direction of the centripetal or centrifugal influences, or in that of any intermediate point between the two; although these, nevertheless, constitute the *directions* in which all forces act that proceed in straight lines, and produce effects directly either *to* or *from* their own centres; or which could have affected the earth in any line perpendicular to its axis.

SECTION VIII.

CONCENTRATION OF THE LIGHT AROUND THE SUN; AND THE COMPLETION OF THE WORK OF CREATION.

CHAPTER XXXVIII.

Preparatory observations. Unique nature of the force which occasioned the protorotation of the earth, and other spheres of our system. Supposed to be identical with electro-magnetism. This description of force defined, and described more minutely from scientific sources. Also the movement of rotation which frequently accompanies the exhibition of this kind of electricity. Confirmatory evidence deducible from the single motion, or non-diurnal rotation of the moon. Concluding inferences.

THE conclusions come to at the close of the preceding chapter are very important, and likely to exercise considerable influence over the future argument. Convinced of this, as well as of the certainty of the non-rotating sphere having been caused, by a commensurate influence, to revolve around its axis, we are shut up to the alternative of supposing, *that this effect was produced by a force which acted in a manner distinct from any we have yet had occasion to contemplate;* one, for instance, which, while it proceeded in a direction *parallel* to the earth's axis, was capable of sending forth its resultant effects *at right angles* thereto; and, fortunately for this hypothesis, and the fate of this theory, there has been discovered, lately, a force which *causes rotation in planes perpendicular to the line of its direction;* and which, therefore, completely corresponds with the description of force now sought.

This unique impelling power belongs to a class of phenomena hitherto only casually noticed, but to which the attention must now be directed, as far as the state of information regarding it will permit; while I take occasion to observe, that this lately discovered force possesses peculiar interest, when considered with relation to the cosmographical views herein promulgated; for, besides the important circumstance of its producing motion in a direction at right angles to the line of its own progress, it emanates from the subtile fluid, electro-magnetism; an influence which, in turn, is considered

to be of a kin to light and heat*—the element, whose introduction into the material universe is considered to have been the immediate secondary cause of the rotation of the earth, and the other spheres around their respective axis; thus presenting to the contemplative mind a most convincing testimony of the power of that Omnipotent Being, who, after having wielded this potent influence by his word, and having caused it, in the condition it then was, to produce the stupendous and fundamental works of the first three days, could, afterwards, by a mere command, concentrate what remained uncombined of the subtile element around the sun, to impart light and warmth, and life-fostering influences, for ever thereafter, to the myriads of his created beings!

The *sixty-third* Theorem states, "*That* ELECTRO-MAGNETISM *(electricity modified by the physical influences peculiar to certain substances), by overcoming retardation arising from friction, and the obstacle of a resisting medium, maintains perpetual motion. That the force emanating thus mutually from the electric current and the magnetic needle, acts at right angles to the electric current. 'Such circumferential action, arising from the tangential direction of two opposite forces,' being unlike any other power hitherto discovered; for, all other known forces emanating from a point, and acting upon any other, impel in the direction of a line joining these two points.*"

The following are some of the philosophical conclusions on which the foregoing theorem is founded; they place this interesting subject in distinct points of view, and may, therefore, tend more fully to illustrate the peculiar character of the force in question, on which account I beg attention to them.

Mrs. Somerville observes—

"The disturbing effects of the aurora borealis and lightning on the mariner's compass had long been known. In the year 1819, M. Oersted discovered that a current of voltaic electricity exerts a powerful influence on a magnetized needle. This observation has given rise to the theory of electro-magnetism—the most interesting science of modern times, whether it be considered as leading us a step further in generalization, by identifying two agencies hitherto referred to different causes, or as developing a new force, unparalleled in the system of the world; which, overcoming retardation from friction, and the obstacles of a resisting medium, maintains a perpetual motion, often vainly attempted, but apparently impossible to be accomplished by means of any other force, or combination of forces, than the one in question. . . . . .

"All experiments made in this branch of science tend to prove that the force emanating from the electric current, which produces such effects on the magnetic needle, acts at right angles to the current, and is, therefore, unlike any force hitherto known; the action of all the forces in nature being directed in straight lines, as far as we know; for the curves described by the heavenly bodies result from the composition of two direct forces, whereas

* "The discoveries of Oersted, Seebeck, and Faraday, show an intimate connexion between these unseen fluids."—Dr. Thomson, p. 278.

that which is exerted by an electrical current upon either pole of a magnet has no tendency to cause the pole to approach or to recede, but to rotate about it. If the stream of electricity be supposed to pass through the centre of a circle whose plane is perpendicular to the current, the direction of the force exerted by the electricity will always be in the tangent to the circle, or at right angles to its radius;* consequently, the tangential force of the electricity has a tendency to make the pole of a magnet move in a circle round the wire of the battery. Mr. Barlow has proved that the action of each particle of the electric fluid in the wire, on each particle of the magnetic fluid in the needle, varies inversely as the square of the distance.†

Sir John Herschel says—

"*Magnetism* and *electricity*, which had long maintained a distinct existence, and been studied as separate branches of science, are, at length, effectually blended. This is, perhaps, the most satisfactory result which the experimental sciences have ever yet attained. All the phenomena of magnetic polarity, attraction, and repulsion, have, at length, been resolved into one general fact, that two currents of electricity, moving in the same direction, repel, and in contrary directions attract each other. . . . . .

"And, to obliterate all traces of that line of separation which was once so broad, we are now enabled, by the great discovery of Oersted, to communicate, at and during pleasure, to a coiled wire of any metal, indifferently, all the properties of a magnet! its attraction, repulsion, and polarity; and *that* even in a more intense degree than was previously thought to be possible in the best natural magnets. . . . . .

Farther on he continues—

"The connexion of magnetism and electricity had long been suspected, and innumerable fruitless trials had been made to determine the question in the affirmative or negative. . . . . . Of all the philosophers who had speculated on this subject, none had so pertinaciously adhered to the idea of a necessary connexion between the phenomena as Oersted. Baffled often, he returned to the attack; and his perseverance was, at length, rewarded by the complete disclosure of the wonderful phenomena of electro-magnetism. There is something in this which reminds us of the obstinate adherence of Columbus to his notion of the necessary existence of the New World; and the whole history of this beautiful discovery may serve to teach us reliance on those general analogies and parallels between great branches of science, by which one strongly reminds us of another, though no direct connexion appears; as an indication not to be neglected, of a community of origin."‡

We are informed by the compilers of the Encyclopædia Britannica, that—

* In a note Mrs. Somerville adds: "when a stream of positive electricity descends from *p* to *n* in a vertical wire, at right angles to the plane of a horizontal circle, the negative electricity ascends frem *n* to *p*, and the force exerted by the current makes the north pole of a magnet revolve about the wire in the direction of the arrow heads (from left to right), and it makes the south pole revolve in the opposite direction. When the current of positive electricity flows upwards from *n* to *p*, these effects are reversed."

† Connexion of the Sciences, pp. 328, 329

‡ Discourse on Natural Philosophy, Cab. Cyc. pp. 324, 326, 339, 340.

"The cultivation of the new science of voltaic electricity withdrew the attention of experimental philosophers from that of ordinary electricity, ... but the discoveries of Galvani and Volta were destined, in their turn, to pass into the shade, and the intellectual enterprise of the natural philosophers of Europe was directed to new branches of electrical and magnetical science. Guided by theoretical anticipations, Prof. H. C. Oersted, of Copenhagen, in 1820, laid the foundation of the science of *electro-magnetism*. He found that the electrical current of a galvanic trough, when made to pass through a platina wire, acted upon a compass-needle placed below the wire; and, upon repeating the experiment, he discovered the fundamental law, that *the magnetical effect of the voltaic current had a circular motion round the conductor*, or the wire through which the current passed. M. Ampere, of Paris, soon afterwards made the important additional discovery, that two wires, conducting electrical currents, when suspended so as to be capable of motion, *attracted* each other when the currents moved in the *same direction*, and *repelled* each other, when they moved in *opposite* directions; or, to express the fact more simply, *two points of electrical currents repel each other by their similar sides, and attract each other by their opposite sides;* so that, as Prof. Oersted remarks, *an electric current contains a revolving action, exhibiting every appearance of polarity*."*

"It was conceived," says Professor Whewell, "that the whole of natural philosophy must consist in investigating the laws of force by which particles of different substances attracted and repelled, and thus produced motions, or vibrations *to* and *from* the particles. Yet, what were the next great discoveries in physics? The action of a galvanic wire upon a magnet; which is not to attract or repel it, but to turn it to the *right* and *left;* to produce motion, not to or from, but *transverse* to the line drawn to the acting particle."†

In addition to what has already been offered, and in the absence of all direct proof as to the cause of the earth's diurnal rotation, it is satisfactory to be in possession of evidence somewhat corroborative of the opinion which has been given on the subject. I allude to the fact of rotation around an axis being one of the most constant developments of electro-magnetism; and, although, in strict reasoning, this can be offered only as *presumptive* evidence, yet it does not fail to exercise considerable influence in favour of the conclusion come to, THAT THE ROTATION OF THE EARTH WAS ONE OF THE EFFECTS OF THE DEVELOPMENT OF THE HIGHEST POSSIBLE DEGREE OF ELECTRO-MAGNETISM EVER DISPLAYED IN OUR SYSTEM.

The facts alluded to form the evidence for the remaining portion of the *sixty-third* Theorem—"*That in all the experiments undertaken with a design of eliciting the phenomena of electro-magnetism and of magneto-electricity,* ROTATION ROUND AN AXIS *is generally found to accompany them.*"

As the experiments, on which these conclusions are based, are very interesting, a brief description of a few of the most celebrated will, no doubt, be perused with pleasure.

"Rotatory motion," observes Mrs. Somerville, when treating of electro-

* Article Electricity, pp. 573, 574.

† Bridgewater Treatise, p. 369.

magnetism, "was suggested by Dr. Wollaston. Dr. Faraday was the first who actually succeeded in making the pole of a magnet rotate about a vertical conducting wire. In order to limit the action of the electricity to one pole, about two-thirds of a small magnet was immersed in mercury, the lower end being fastened by a thread to the bottom of the vessel containing the mercury. When the magnet was thus floating almost vertically with its north pole above the surface, a current of positive electricity was made to descend perpendicularly through a wire touching the mercury, and immediately the magnet began to rotate from left to right about the wire. The force being uniform, the rotation was accelerated till the tangential force was balanced by the resistance of the mercury, when it became constant. Under the same circumstances the south pole of the magnet rotates from right to left. . . . . .

"The wire has also been made to rotate around the magnet, and even a small battery, consisting of two plates, has performed the rotation. Dr. Faraday produced both motions at the same time in a vessel containing mercury; the wire and the magnet revolved in one direction about a common centre of action, each following the other.

"The next step was to make a magnet, and also a cylinder, revolve about their own axes, which they do with great rapidity. Mercury has been made to rotate by means of voltaic electricity, and Professor Ritchie has exhibited in the Royal Institution, the singular spectacle of the rotation of water by the same means, while the vessel containing it remained stationary. . . . . .

"It appears," in fine, "that the principle and characteristic phenomena of the electro-magnetic science are, the evolution of a tangential and rotatory force exerted between a conducting body and a magnet; and the transverse induction of magnetism by the conducting body in such substances as are susceptible of it."*

We learn from the Encyclopædia Britannica that,

"The discovery of thermo-electricity by Dr. Seebeck in 1822, gave a new impulse to this branch of science," for, "in the same year in which he made this remarkable discovery, the rotation of a magnetical needle round an electrical current, and of a body transmitting an electrical current round a magnet, were exhibited in a series of beautiful and highly ingenious experiments by Dr. Faraday, whose subsequent discoveries place him at the head of the cultivators of this most interesting science.

"These experiments were followed by those of Arago, Barlow, Seebeck, Herschel, and Babbage, in which a revolving plate of copper gives a rotatory motion to a magnetic needle conveniently suspended; but notwithstanding the ingenuity and talent with which this subject was treated by these eminent individuals, it is to Dr. Faraday that we owe the complete analysis and explanation of this curious phenomenon."†

Somewhat further on, in the same work, it is stated that

"This tendency of points to discharge their electricity against the surrounding air enables us to perform some beautiful electrical experiments, in which the motion of rotation is effected.

"The *Electrical Orrery*, as it is called, is founded on this principle. A

* Connexion of the Sciences, pp. 330, 333. † Article Electricity, p. 574.

spherical ball of metal S, representing the sun, has its inner concave surface supported on a pivot on the top of an insulated stand. From the ball S extends a wire, the turned up extremity of which supports upon a pivot another ball E, which represents the earth, having a wire passing through it, and carrying at one end a smaller ball M, representing the moon, while the other is bent into a sharp point; a sharp point H being also fixed to the arm E F. If these balls are electrified by a chain which connects them with the prime conductor, the discharge from the point H will give a rotatory motion to the arm to which is affixed the earth E, while the electrical discharge from the point N, will give a rotatory motion to the moon M round the earth E. In this manner the moon revolves round the earth, while the earth and moon together are carried round the sun."*

Indeed, every proof on this subject tends more and more to strengthen the position, that the introduction of the primary light into the material universe, and its division from the darkness, on the first day of the Mosaic week, occasioned the most stupendous of all instances of electro-magnetic rotation—that of the sun and its attendant orbs around their respective axis; and that it was the same principle which, at a far anterior period in the history of creation, occasioned the more simple orbital motions of the spheres of our solar economy, and those of all the other, then unillumined, systems of the universe.

In further corroboration of what has been stated with respect to the *description of force* which is considered to have occasioned these effects, namely—the rotatory motion of the earth and other primary planets—and which may be looked upon as presumptive evidences of a *positive* character, I proceed to adduce an instance of the most confirmatory kind, although partaking of an entirely opposite nature, proof *negative*, or that which is afforded by a well-defined exception to the general law so frequently referred to—namely, the MOON, our attendant satellite, which performs its double revolution by means of *one* motion in space; that around the earth in 27 days, 7 hours, and 43 minutes.

To prepare the mind for what may be said, let us recapitulate the *ninth* Theorem; exclusively dedicated to our companion in space—which is therein stated to have *a triple revolution; one by which it accompanies its primary around the sun, and a binary movement (performed by the same motion in 27 days, 7 hours, 43′ 11″), consisting of its sidereal path around the earth, and rotation around its axis. That owing to this double revolution by a single movement, together with its libration, and slight obliquity of axis, the same hemisphere, increased by a narrow zone occasionally seen on either side, presents itself invariably towards the earth. And that no indication of either continents or oceans presents itself on the earthward disc, although it affords manifestations of being extremely mountainous, the elevations appearing to have originated from volcanoes, now extinct.*"

* Article Electricity, pp. 591, 592.

From the very moment of its existence, and for ages before rotatory movement had been impressed upon the earth, *the moon must have performed, in perfect darkness, the identical orbital motion which it still continues to do;* consequently, the fact of its remaining unaffected when the material light, by being introduced into the universe, and, when by its expansive influence, it had conferred an additional motion on the primary planets, shows, in language which cannot be misunderstood, that there was something *peculiar* in the *new propelling force* which was then introduced into the creation. It must have been wholly different from *attraction*, which, disregardful of the constituent materials of bodies, acts upon all *merely according to their mass*. But if the new force which emanated from the primary light, was not thus impartial and indiscriminate, *it must have belonged to those which act by election;* the constituent elements of the mass, on which they impinge, entering so thoroughly into the operation, that on these elements it depends almost entirely whether action takes place or not. Of this description of force there are two varieties known—MAGNETISM and CHEMICAL AFFINITY. Although by some it is considered, that those two influences are merely modifications of the same power; yet, they not only can, but in this case they do require to be treated separately; the latter, *chemical affinity*, being entirely restricted to inter-molecular movements, which, by it, are caused to take place in bodies within the boundaries of each particular sphere; circumscribed, as it were, within the economy of a world; while *magnetic*, and certainly *electro-magnetic* influences seem to extend throughout the whole range of each system. *Chemical affinity* has the molecules of an orb within its grasp; *electro-magnetism* has, for its dominion, the orbs themselves, the molecules of a system; consequently, there can be no hesitation in eliminating *chemical* affinity from the present argument, and fixing the undivided attention upon its more comprehensive congenial power—ELECTRO-MAGNETISM.

This, it is well known, is so far dependent for its action on the peculiar elements of the body with which it is brought into contact, that on some *it exercises no influence whatever*. Now it is certain that there was a period, measureable by the *time* necessary to form the materials of the stratified crust of the globe, during which the world had no rotation around its axis; that during those protracted ages, the moon revolved around the earth, and its own axis, in the precise orbit and by the same simple motion with which it continues still to perform that double movement in space; and, that while it was thus engaged, there overcame a great change upon the earth, which it attended in its path through the heavens. The earth being made to revolve around *its* axis without experiencing either the slightest derangement of orbit, or deviation in its measured way, as it wheeled around *its* primary, the sun; and what is still more remarkable, without the smallest sensation being perceived by

the moon, or any change produced upon its original motion. The latter continued its monthly course around the earth, with as imperceptible a variation as the earth experienced in its more protracted circuit around the sun. Therefore it is perfectly justifiable to conclude, that the force which wheeled the earth around its axis without acting on its orbital motion, or upon its attendant satellite, *was of that description which acts by* ELECTION; and *that the moon did not contain the peculiar materials required to render the then newly-formed force effective;* but, on the contrary, that the earth and all planetary and stellar bodies which have rotatory motion, do possess those qualifications and were acted upon accordingly. What those qualifications are, it may be somewhat difficult to determine; nevertheless, we are not wholly without the data requisite to hazard an opinion.

So far the facts warrant the belief, that the force employed was altogether different from attraction, which manifests no affinity whatever, acts in straight lines, and exercises a mutual, indiscriminate power, in proportion solely to the mass of the respective bodies; and, therefore, it is the more natural to consider, that the new force acted tangentially, and also had regard to the peculiar nature of the elements composing the bodies with which it was brought into contact. Such a force, possessing magneto-electro energies, and impinging on the solar system, in the direction supposed, with respect to the plane of the ecliptic, would produce rotatory motion in some spheres, while it left others to revolve around their primaries *wholly unaffected by its presence;* the rotation being produced at right angles to the line in which the expansive force travelled when it came into contact with the revolving bodies.

The concurring circumstances of the seeming absence of oceans or other collections of water on the moon's surface; the consequent impossibility of there ever having been any stratiform depositions there; and the conclusion arrived at, from the scarped and rugged appearance of its mountain masses, that they have not been filled up or rounded off by water-borne debris; are coincidences—when taken in addition to its non-rotation, and compared with an opposite state of geological development on the earth and its diurnal rotation —of too great importance to be allowed to pass without special notice.

They are, indeed, *very strong corroborations of the Dynamical Theory;* and, if thoroughly investigated, are capable of designating more clearly the special agency made use of by the Creator to turn this great globe, and all other rotating spheres around their respective axis. This, it has all along been maintained, was the primary light, when first transformed into the expansive influence, aided by the stratiform masses of the earth's outer crust which, no doubt, performed a very important part in this powerful leverage. In fact this seems to have been one of the many co-purposes for which

these concentric stony masses were originally formed by deposition during ages, and while as yet the earth had no movement around its axis.

Nor need any convictions, which these reflections may have raised in the mind, be damped by the apparent incompatibility of the results compared with the cause; that is, *an instantaneous and uniform motion, and a continued force of three days;* for, we have been made aware, "that one of the most usual features in electro-magnetic experiments is, that after a short while, and the attainment of a certain equilibrium, a *continued action* produces a *uniform motion.*"*

While the moon is thus adduced as another and a very striking instance of a supposed objection resolving itself into a confirmatory evidence, the reader should be reminded that the subtile expansive influence, whose origin and nature at the *first* we are endeavouring to investigate, was destined to perform other stupendous works on the *second* and the *third* days of the Mosaic week—works of such a character that inconceivable volumes of the expansive principle must have been and were permanently employed in producing them. By the Creator's powerful and unerring hand, the same element stretched the firmament like a spread-out curtain over our heads; caused the watery vapour to arise and expand throughout its aerial extent, which still sustains and invigorates the whole of the vegetable kingdom, which, also by its impartation, rose in such beneficial and attractive forms above the level of the earthy soil, and still spread forth their beautiful towering stems and shady branches in testimony of his power and faithfulness, and benignity to his creatures. These works, of wondrous extent, were quite sufficient, of themselves, to have expended the electro-magnetic force, which was put into energy on the *second* and *third* days, even was there not the additional evidence, in the law previously referred to, of a uniform motion being the result of a continued application of the magnetic current; while a faint conception of the amazing amount of electrical fluid which must have been employed, in producing and perfecting these world-wide works, may be obtained by the knowledge of the fact, that, by repeated and well-attested experiments, Dr. Faraday has shown, "that the quantity of electricity holding the elements of a single grain of water in chemical combination would, if discharged under the form of a current, through a wire of platinum, about the 1-104th part of an inch in diameter, keep it red hot in the air for nearly four minutes."

In further confirmation of this particular part of the subject, and in order to accumulate every possible evidence, I would mention the relative direction of the moon's axis, when compared with that of the earth, as another modicum of evidence which may be turned to account.

Although the plane of the moon's orbit be inclined 5° 8′ 48″ to

* Connexion of the Sciences, 3rd edition, p. 330.

that of the earth, nevertheless, the axis of the satellite being almost perpendicular to the plane of its own orbit, shows that the single movement, whereby it performs a double motion in space, is the same now as when first created; that it still retains the identical position which it did when circulating around the earth and its own axis, ages before it was shown upon by the rays of that sun around which it accompanied its primary, in comparative unusefulness. The Dynamical Theory of the earth's formation—based alike on the announcements of Scripture and the revelations of Science—opens up to the imagination, in the clearest manner, some retrospective views of the wonders of Creation, and the events which were taking place in the material universe, long before there was an eye to behold, or a pen to record them. When brought under the notice of minds thoroughly trained by those scientific researches to which it has reference, it will be the means of unfolding to the world's inhabitants vastly improved conceptions of the wisdom and goodness of the Creator!

It is scarcely possible, with any degree of certainty, to demonstrate the course observed by the primary light when it was made the instrument of causing the rotation of our globe. I can produce no miniature sphere encoated, layer above layer, with electric generating materials of brittle mould, surrounded by a zone of acidulated water, and freely poised in mid-air, ready to revolve; and then, by applying the voltaic current, exhibit its rotation, the breaking up of its concentric crust; the rising of its tiny continents, and the thrusting up of its inimitative mountain peaks, the depression of its miniature ocean hollows, and the rush of its mimic oceans from the poles to the equator: but so surely as all these manifestations of protorotation exist in real grandeur on the surface of the earth we tread on, and that they can be seen, touched, examined, and commented upon, so sure is it, that there was power enough in the primary light, virtue enough in the concentric strata and ancient ocean, and time enough of darkened circuit through the etherless heavens (whereby the non-rotating sphere may have become sufficiently electrified) to cause the earth to arise from its slumber of ages and to perform its first diurnal revolution —and thereby to occasion the magnificent diversity of appearance which its expanded surface now happily presents. And moreover, although dim in the distance, yet those wonderful arcanæ of creation can be so far penetrated as to perceive traces, faint, indeed, but true outlines of the working of the secondary forces which were made the instruments of the first revolution of this our pedestal around one of its diameters, which had previously held no pre-eminence over any of the others.

It can be recognized, for example, that between two justly equipoised forces it was sustained in space, made to revolve around the centre of gravity of the system, and held perfectly free to rotate

whenever diurnal motion should be expedient. It has been shown that the LIGHT, or expansive principle, had not the sun for its centre during the first three days of its existence; and this of itself assists materially to solve the problem, because the solar centre is that alone from whence an emanation of the expansive principle could *not* have caused rotation. This and the attractive influence would, in that case, have travelled in parallel lines though in opposing directions, and therefore could not by their conjoint influence have produced a *tangential* result; but not being in or around the sun, *any other centre whatever* would have produced an oblique direction, lesser or greater according to the angle, and consequently an oblique impulse upon the one previously established, namely, Gravity—which passed then, as now, through the sun—the light not having been resident where it now is; it may be assumed to have been *anywhere* else. We are at liberty to suppose, that the motion which was given to the primary light, or the ethereal fluid, when it was divided from the darkness, was in any direction relative to attraction, which was most conducive to the objects then to be wrought out by its impulse. Its present *residence* around the sun having no necessary connexion with *light*, any further than that its being *now* there is conducive to the welfare of myriads of beings, whose adapted construction would render them incapable of existence without it were so; yet, before it pleased the Omnipotent to concentrate light in that part of our system, the sun had not only no inherent relation to the subtile influence whose first effects I am now endeavouring to demonstrate; but was, of all other bodies, the least likely then to be the centre of the direction of expansion.

From what has been said, therefore, it is legitimate to conclude, that the peculiar construction and mineral character of the stratified materials of the ancient earth were designed, amongst other purposes, to serve as a galvanic girdle of universal extent, that the circumfluent ocean was intended to be a general receptacle for the acidulated fluid so indispensable in all electro-magnetic operations; and, that, being thus predisposed, by the wise forethought of the Creator, the expansive influence, emanating from the newly-formed light, was made to impinge upon the system in a direction somewhat perpendicular to the plane of the ecliptic, or parallel to the axis of rotation of each planet, and by its tangential influence to induce rotation at right angles to the direction in which it travelled through space, in a manner similar to that in which *electro-magnetism* affects objects of its affinity; and occasions rotation where the axis is fixed, and the body free to revolve.

Every other direction in which the impelling force could have impinged upon the earth, so as to have overcome the inertia of a world diurnally at rest, has been shown to be objectionable; any one of them would have disturbed the perfect equipoise of the countervailing forces required to restrain the earth in its orbital path;

and which confer upon it an axis round which it can with freedom revolve; *the line of the direction of the sun's rays, as they travel at present, being the most objectionable of all the others.* To these evidences—which are the legitimate deductions of scientific research—there is merely to be added the concurring testimony, amounting to proof presumptive, which can be drawn from the announcements of Scripture, and which, when adopted without bias, leave not a doubt upon the mind, that, on the fourth day of the Mosaic week, the LIGHT was concentrated, by the Creator, around the central orb of our system; and, shedding its rays from thence upon our attendant luminary, it caused a lesser degree of light to shine, by reflection, upon the earth, when, by diurnal rotation, the direct rays of the sun were hidden from our view. In that portion of Scripture we are informed, as distinctly as language is capable of implying, that, on the fourth day of the Mosaic week, the light was concentrated around the sun, and thereby made to enlighten the moon, so that she should shed on us a lesser light; and, consequently, the very fact that this was performed on the *fourth* day, proves beyond the possibility of a doubt, that the primary light did not encircle that luminary during the *first three days* of its existence. And if it did not—which has been clearly demonstrated by proofs derived from several sources—then it may as well be considered *to have been situated, as has been supposed, in accordance with what electro-magnetism may hereafter demand on further investigation;* or, in other words, *in that state which is most accordant with the effects which have flowed from it.*

Notwithstanding the apparent conclusiveness of the evidences which have been brought forward from so many converging sources, it may still be attempted to be denied that the protorotation of the earth commenced at an epoch so late in the history of its existence as that which the Dynamical Theory assumes, and requires for its complete establishment; and, probably, the bygone error of supposing, that rotatory motion was impressed upon the earth by the same projectile impulse by which it was translated in space, may be attempted to be upheld in opposition. Fortunately, however, the fulcrum on which the main argument rests is too secure, and too tangible to the senses to be so easily set aside. Every scarped peak of primary granite, which has displaced the once superincumbent stratiform masses, and towers its head above them, enveloped by the fleeting clouds around, affords the surest proof of the faithfulness of these assertions; for, as durable and undeniable as are those elevated masses of solid rock, so indestructible are the proofs which are deduced from them; and as transient as are the passing clouds which may, for a moment, obscure them from the view, so evanescent must be every attempt to deny that their elevation was caused by the first rotation of the earth around its axis, ages after it had been brought into existence, and when sufficient time had been

afforded for the once superincumbent strata to settle down in concentric superposition, and to arrange themselves into those levers which were afterwards to contribute so essentially to the overcoming of the earth's inertia, and to the upheaving of its continental ridges!

Before taking leave of this interesting part of the subject, it may be observed, that the whole tenor of the discourse puts an end to all fanciful or figurative conceptions which have been applied to the *duration of the day,* so frequently mentioned in this introductory part of Scripture.

The Dynamical Theory maintains, that it was a *natural day of twenty-four hours,* and requires, for its completion, the centrifugal impetus arising from the rotatory motion of 15° per hour, which the limitation of the above period, within natural bounds, can alone supply; and it besides requires, that this force should have been put forth simultaneously with the introduction of the light, or rather, that this should have been the cause of the upheaving of the continents and mountains, and the depression of the oceanic hollows, &c., as stated. For if the day were supposed to have been longer than twenty-four hours, there would be a deficiency of dynamical power to which to attribute the numerous inequalities of the earth's surface; while, on the other hand, if it be presumed that these geographical features have existed ever since the sphere was translated in space, besides the difficulty of accounting for their origin, there would be the dynamical power of rotation, at the rate of 15° per hour, too much, by having no adequate objects on which to show that it was expended. This theory brings all those data to be at one, and perfectly reconciles them. By assuming the protorotation of the earth to have taken place, as in reality it did, on the first day of the Mosaic week, by considering the specified period "of evening and morning," to have been a natural day, measured by a revolution of the earth around its axis, and by attributing the change of form which it underwent, and the diversified appearance of its surface to the force which this rapid diurnal movement, so instantaneously communicated, necessarily produced, we are relieved from all perplexity of mind, and made to see the whole to be parts of one grand and comprehensive plan: *the work of creation, carried on through innumerable ages, but completed in six natural days.*

SECTION VIII.

CONCENTRATION OF THE LIGHT AROUND THE SUN; AND THE COMPLETION OF THE WORK OF CREATION.

CHAPTER XXXIX.

The concentration of the primary light treated scientifically. The earth a non-luminous body, receiving its external light and heat from the sun. Considerations which result from this fact. Constitution of the solar light enquired into by a consecutive series of investigations. Polarization of light: sun's rays not possessing this remarkable property. Therefore not proceeding from an incandescent body, but from a luminiferous atmosphere. The same argument followed up by another approach. Identity of Electricity and Light, and of the various kinds of electricity with one another. Intimacy subsisting between Electricity and Magnetism. Terrestrial magnetism. Scientific investigations respecting the origin of these recondite magnetic currents. And, in conclusion of this chapter, evidences to prove that Light, Heat, Electricity, and Magnetism, are considered to be diversified manifestations of the same comprehensive law of nature.

In the prosecution of the subject during the present chapter, I have to direct the attention to the fact that "the earth is, of itself, a non-luminous body, receiving its external light and heat from the sun;" and, then, to the following considerations which arise from it; namely, that there are only *two* ways in which the earth could, at this particular period, have been made to receive light and heat from another orb around which it circulates. Firstly, the simultaneous formation of the material body of the sun, *with its luminiferous powers;* and its being placed, thus doubly constituted, into the centre alike of attraction and of expansion; and then causing the earth to revolve in its orbital path around it. Or, secondly, by supposing the material part of the sun to have been *previously* in existence, although *not illuminated*, the earth revolving around it by the same laws by which it now does; and that while in this state, the light was made to concentrate around the previously dark nucleus as a *luminiferous atmosphere*, dispensing rays from every point of its equatorial circumference.

Against the *first* of these suppositions there are very many and insuperable objections. It is inconsistent, with what is known respecting the laws of matter, to conceive the existence of the earth, not only

for three days, but for as many seconds, without presupposing the existence, likewise, of the other planets, and the *material body of the sun,* as counterpoises to one another, in the mutual system of which the earth forms only one member. Again, it is impossible to imagine the existence of matter without attraction, or attraction in the solar system without revolution in appointed orbits through space; for without this last counterpoise to attraction the material universe would have gravitated into one vast and boundless whole—a universe of undivided matter! But if revolution in space be admitted, then there must needs have been a central mass round which, and the common centre of gravity, the revolution was to be performed by the revolving bodies; while, in addition to all other objections, there can be adduced the words of the record itself—"Let there be lights *in the firmament* of heaven:" for who, after having been made acquainted with the nature and constitution of the firmament, could, for a moment, suppose this to apply to the *material* bodies of the sun and moon, or imagine that it was ever meant that the firmament should be capable of upholding them, on the *fourth* day, in addition to those already in our system? Not so with respect to the latter of the two suppositions formerly mentioned; for then every conclusion is as consistently favourable to it as they are adverse to the former. According to the natural interpretation, or strict signification of the Mosaic narrative, there was only this addition made to the laws which had been previously established. *That there should be* LIGHTS, a *primary* and a *secondary* light, introduced *into the firmament of heaven;* and which, by the mere act of being "*set there,*" were to become, to the earth, "signs, seasons, days, and years." In this no mention is made of causing the one sphere to revolve around the other; or of forming the solid materials of those luminaries which were to produce these effects; but it is *strictly confined to the lights themselves,* one of which was to be *greater* than the other, and they were to be "set in the firmament of heaven," which, from our knowledge of the *earthly* firmament, must be presumed to allude to *the firmament of the sun.*

Meditating upon this passage, under the consciousness of the earth having for ages revolved around the unilluminated solid nucleus of the sun, which assuredly was then the condition of our planet, its peculiar harmony will be recognized, not only with all the laws formerly instituted, but likewise with the original structure of the materials of the earth itself; while no difficulty will ever afterwards be experienced in fully comprehending this passage of Scripture, which, while it accounts for this wonderful operation, is remarkable for the characteristic and convincing simplicity of the words in which it is couched:—language which, alone, could be employed by the Omnipotent, when he graciously informs us of the primary light being made to remain permanently in the centre of the system; and what a God-like labour it was, to cause that which, by its characteris-

tic tendency, *propends towards the circumference, to concentrate itself around the central orb of our system,* and there to remain fixed and immovable to fulfil his future designs! Besides, it agrees most admirably with those views at present entertained, and considered to be the most scientific as to the *nature* and *constitution* of the *solar atmosphere.* To verify this, while I may be allowed, for the unity of our argument, to disregard, as irrelevant to the enquiry, the merits of the contending theories respecting the intimate nature of light; a branch of natural phenomena, connected more directly with the luminiferous atmosphere which is supposed to surround the sun, will be followed up. The *second* part of the *thirty-ninth* Theorem states—"*That a pencil of light, by the skilful application of certain refracting and absorbing media, can be polarized or separated into two distinct pencils; one whose pole is* + 45°, *and the other having its pole* — 45°.

This interesting announcement being essential to the future argument, some of the evidences on which it is founded will be given in continuation.

Mrs. Somerville bears the following testimony:—

"In 1808, while M. Malus was viewing, with a doubly refracting prism, a brilliant sunset reflected from the windows of the Luxembourg Palace, in Paris, on turning the prism slowly round, he was surprised to see a very great difference in the intensity of the two images, the most refracted alternately changing from brightness to obscurity at each quadrant of revolution. A phenomenon so unlooked for, induced him to investigate its cause, and from this sprung one of the most elegant and refined branches of physical optics. . . . . .

"In giving a sketch of the constitution of light," she observes at another place, "it is impossible to omit the extraordinary property of its polarization. . . . . .

"Light is said to be polarized, which, by being once reflected or refracted, is rendered incapable of being again reflected or refracted at certain angles. . . . . .

"If a ray of light be reflected from a pane of plate glass at an angle of 57°, it is rendered totally incapable of reflection at the surface of another pane of glass, in certain definite positions, but it will be completely reflected by a second pane in other positions. It likewise loses the property of penetrating transparent bodies in particular positions, whilst it is freely transmitted by them in others. Light so modified as to be incapable of reflection and transmission in certain directions is said to be polarized. This name was originally adopted from an imaginary analogy in the arrangement of the particles of light, on the corpuscular doctrine, to the poles of a magnet, and is still retained in the undulatory theory. . . . . . The angles at which different substances polarize light are determined by a very simple and elegant law, discovered by Sir David Brewster, 'that the tangent of the polarizing angle for any medium is equal to the sine of the angle of incidence, divided by the sine of the angle of refraction of that medium;' whence also the refractive power even of an opaque body is known, when its polarizing angle has been determined. . . . . .

And again, from this authoress—

"It appears, from what has been said, that the molecules of ether always perform their vibrations at right angles to the direction of the ray, but very differently in the various kinds of light. In natural light the vibrations are rectilinear, and in every plane. In ordinary polarized light they are rectilinear, but confined to one plane; in circular polarization the vibrations are circular; and in elliptical polarization, the molecules vibrate in ellipses.

"These vibrations are communicated from molecule to molecule in straight lines when they are rectilinear, in a circular helix when they are circular, and in an oval or elliptical helix when elliptical."*

Sir David Brewster affords the following evidence, which is given so circumstantially, because it is inconsistent with perspicuity to abridge it:—

"A beam of solar light has the same properties on all its sides; and this is true, whether it is white light as directly emitted from the sun, or light of any other colour, or whether emitted from a candle, or any burning or self-luminous body, and all such light is called *common* light. . . . . .

"If we allow the same beam of light to fall upon a rhomb of Iceland spar, and examine the two circular beams *O E*, formed by double refraction, we shall find—

"That the beams *O E* have different properties on different sides, so that each of them differs, in this respect, from the beam of common light.

"These two beams, *O E*, are, therefore, said to be beams of *polarized* light, because they have sides or poles of different properties.

"Now, it is a curious fact, that if we cause the two polarized beams *O E* to be united into one, or if we produce them by a thin plate of Iceland spar, which is not capable of separating them, we obtain a beam which has exactly the same properties as a beam of common light.

"Hence we infer, that a beam of common light consists of two beams of polarized light, whose planes of polarization, or whose diameters of similar properties are at right angles to one another, ... from which it follows, that there are three ways of converting a beam of common light into a beam of polarized light.

"1. We may separate the beam of common light into its two component parts, *O E*.

"2. We may turn round the two planes of polarization till they coincide, or are parallel to each other; or,

"3. We may absorb or stop one of the beams and leave the other, which will, consequently, be in a state of polarization." . . . . .

"It does not appear, he continues, "from the preceding experiments, that the polarization of the two pencils is the effect of any polarizing force resident in the Iceland spar, or of any change produced upon the light. The Iceland spar has merely separated the common light into its two elements, according to a different law, in the same manner as a prism separates all the seven colours of the spectrum from the compound white beam, by its power of refracting these elementary colours in different degrees. The re-union of the two oppositely polarized pencils produces common light, in the same manner as the re-union of the seven colours produces white light."†

* Connexion of the Sciences, pp. 219, 200—217.
† Optics, in Cab. Cyc. p. 157.

Sir John Herschel may be said to have summed up the evidence regarding these optical discoveries, when he favours us with the following account of their progress, which it has here been requisite to abridge:—

"After a long torpor," he observes, "the knowledge of the properties of light began to make fresh progress about the end of the last century, advancing with an accelerated rapidity, which has continued unabated to the present time. The example was set by Dr. Wollaston, who re-examined and verified the law of double refraction in Iceland spar, announced by Huyghens. . . . . . The prosecution of the subject was encouraged by the offer of a prize on the part of the French Academy of Science; and it was in a memoir which received this honourable reward, in 1810, that M. Malus, a retired officer of engineers in the French army, announced the great discovery of the *polarisation of light*, by ordinary reflection, at the surface of a transparent body. . . . .

"This was the first circumstance which pointed out a connexion between that hitherto mysterious phenomenon and any of the ordinary modifications of light; and it ultimately proved the means of bringing the whole within the limits, if not of a complete explanation, at least of a highly plausible theoretical representation. . . . .

"The new class of phenomena thus disclosed was immediately studied with diligence and success, both abroad by Malus and Arago, and at home by Dr. Brewster, when another and, apparently, still more extraordinary class of phenomena presented itself in the production of the most vivid and beautiful colours, ... whose attentive examination soon excited the highest interest—that sort of interest which is raised when we feel we are on the eve of some extraordinary discovery. . . . .

"This expectation was not disappointed. The late Dr. Thomas Young had been led to the idea that the same ought to hold good with light as with sound; and that, therefore, two rays of light, setting off from the same origin at the same instant, and arriving at the same place by different routes, ought to strengthen, or wholly or partially destroy each other's effects, according to the difference in length of the routes described by them.

"That two lights should, in any circumstances, combine to produce darkness, may be considered strange, but is *literally true*. . . . . The experimental means by which Dr. Young confirmed this principle were as simple and satisfactory as the principle itself is beautiful; but the verification of it, drawn from the explanation it affords of phenomena apparently the most remote, is still more so. . . . .

"Nothing now was wanting, indeed, to a rational theory of double refraction but to frame an hypothesis of some mode in which light might be conceived to be propagated through the elastic medium supposed to convey it in such a way as not to be contradictory to any of the facts, nor to the general laws of dynamics. This essential idea . . . . . was also furnished by Dr. Young, who, with a sagacity which would have done honour to Newton himself, had declared that, to accommodate the doctrine of Huyghens to the phenomena of polarized light, it is necessary to conceive the mode of propagation of a luminous impulse through the ether, differently from that of a sonorous one through the air. In the latter the particles of the

air *advance* and *recede;* in the former those of the ether must be supposed to *tremble laterally*. . . . . .

"M. Freswell succeeded in erecting on this hypothesis a theory of polarization and double refraction so happy in its adaptation to facts, and in the coincidence with experience of results deduced from it by the most intricate analyses, that it is difficult to conceive it unfounded. . . . . . And so long as it serves to group together in one comprehensive point of view, a mass of facts, almost infinite in number and variety, to reason from one to another, and to establish analogies and relations between them, ... it can never be regarded as other than a most real and important accession to our knowledge. . . . . . Indeed, the science of optics, in this respect, has rendered to mineralogy and crystalography services not less important than to astronomy by the invention of the telescope, or to natural history by that of the microscope; while the relations which have been discovered to exist between the optical properties of bodies and their crystaline forms, and even their chemical habitudes, have afforded numerous and beautiful instances of general laws concluded from laborious and pains-taking induction, and curiously exemplifying the simplicity of nature, as it emerges slowly from an entangled mass of particulars, in which, at first, neither order nor connection can be traced."*

Having shown what is implied by the *polarization* of light, the intended application must now be made of it to the present argument. The *forty-second* Theorem states:—"*That some late and delicate experiments in optics having proved, that rays from the sun, even when transmitted obliquely, are not polarized, whereas those which emanate from incandescent bodies possess this remarkable property, it follows as a consequence, that solar light does not issue from an incandescent solid or fluid, but rather—as Herschel previously supposed—from an exterior film which is the source of its light; and that the intensity of the sun's light diminishes from the centre to the circumference of the solar disc.*"

The following, which are the details, will no doubt be read with pleasure:—

"The sun," observes Mrs. Somerville, "has a very dense atmosphere. What his body may be, it is impossible to conjecture; but he seems to be surrounded by a mottled ocean of flame, through which his dark, dark nucleus appears like black spots, often of enormous size. These spots are almost always comprised within a zone of the sun's surface, whose breadth, measured on a solar meridian, does not extend beyond 30½° on each side of his equator, though they have been seen at the distance of 39½°. From their extensive and rapid changes, there is every reason to suppose, that the exterior and incandescent part of the sun is gaseous. The solar rays, probably arising from chemical processes that continually take place at his surface, or from electricity, are transmitted through space in all directions; but, notwithstanding the sun's magnitude, and the inconceivable heat which must exist at his surface, as the intensity both of his light and heat diminishes as the square of the distance increases, his kindly influence can hardly be felt at the boundaries of our system; or, at all events, it must be but feeble."†

* Discourse on Natural Philosophy, Cab. Cyc. pp. 257—264.

† Connexion of the Sciences, p. 254.

"From the fact," observes Sir John Herschel, "that the most vivid flames disappear, and the most intensely ignited solids appear only as black spots on the disc of the sun when held between it and the eye, it follows, that the body of the sun, however dark it may appear when seen through its spots, *may*, nevertheless, be in a state of the most intense ignition. It does not, however, follow of necessity that it *must* be so. The contrary is at least physically possible. A *perfectly reflective* canopy would effectually defend it from the radiation of the luminous regions above its atmosphere, and no heat would be conducted downwards through a gaseous medium increasing rapidly in density. That the penumbral clouds are highly reflective, the fact of their visibility in such a situation can leave no doubt.

"The immense escape of heat by radiation, we may also remark, will fully explain the constant state of tumultuous agitation in which the fluids composing the visible surface are maintained, and the continual generation and filling in of *the pores*, without having recourse to internal causes. . . .

"The great mystery, however, is to conceive how so enormous a conflagration (if such it be) can be kept up. Every discovery in chemical science leaves us here completely at a loss, or rather, seems to remove further the prospect of probable explanation. If conjecture might be hazarded, we would look rather to the known possibility of an immediate generation of heat by friction, or to its excitement by the electric discharge, than to any actual combustion of ponderable fuel, whether solid or gaseous, for the origin of the solar radiation."*

"There is no obvious connection," observes Professor Whewell, "between mass and luminiferousness, or temperature. No one, probably, will contend that the materials of our system are necessarily luminous or hot. According to the conjectures of astronomers, the heat and light of the sun do not reside in its mass, but in a coating which lies on its surface."†

"It followed at once," Mr. Nichol asserts, "from Wilson's capital achievement, that our magnificent luminary is no chaotic conflagration, as had hitherto been supposed; and to the investigation of what it really is, the singular powers of the elder Herschel came quickly in aid of the efforts of his friend. With both of these illustrious men it seemed an unquestionable first impression, that the surface thus broken by chasms must be an elastic or gaseous fluid; for notwithstanding the magnitude of the spots, sometimes reaching even 50,000 miles in diameter, they open and close with a rapidity altogether marvellous, often surpassing the rate of a thousand miles a day. Granting, then, that this light-giving surface is some phosphorescent gas, what is the umbra and what the dark internal spaces? To these engrossing questions, Herschel, without delay, applied the energies of a mind that ever and anon was flashing into the unknown. It seemed to that penetrating genius, and no other theory will yet resolve the fact, that the sun consists mainly of a dark mass, like the body of the earth and other planetary globes, which is surrounded by two atmospheres of enormous depths, the one nearest to him being, like our own, cloudy and dense; while the loftier stratum consists of these dazzling phosphorescent zephyrs that bestow light and heat on so many surrounding spheres. In this view the following is the real meaning of a solar spot. By some unknown force from below, these atmospheres are disturbed and opened, the phosphores-

* Astronomy, Cab. Cyc., American edition, pp. 200—202.
† Bridgewater Treatise, p. 171.

cent zephyrs being flung aside, we descry the dark clouds or shelving edges reflecting somewhat of the light beaming on them from above, which is the *umbra* below, the darker and more sombre, because more sheltered body of the great globe, as the central spot. Nor in all the annals of discovery is there aught that stirs thought, or raises more strange questions than this !" (*Contemplation of the Solar System*, pp. 173, 174.)*

These impartial and quite unconscious evidences are very interesting; and when considered, more especially with reference to the opinions expressed in this theory, as to the existence of the *material* nucleus of the sun, of the earth, and of the other planetary bodies of our system, for ages previous to the formation of the light on the *first* day of the Mosaic week; together with the close conformity which the idea, of *a luminiferous atmosphere* around the sun, has to the spirit and the expressive words of scripture, all remaining doubts will assuredly be dispelled.

The announcements of the inspired historian apply much more obviously to the illumination of an atmosphere, than to that of a solid body—"Let there be lights (or, as in the marginal reading 'luminaries,') in the firmament of the heaven," and when we reflect on what is meant by a "*firmament*," it is almost impossible any longer to hesitate in admitting, that the views adopted by MM. Herschel, Wilson, Arago, Whewell, Nichol, and others are correct; for the laws which governed matter, even before the formation of the light, must have been complete, and thoroughly consistent among themselves, and with the state in which every thing then was; it being impossible to conceive, that there ever could have been a void in the laws of the material universe! Besides, it is much more consistent with the acknowledged conceptions of the wisdom of the Omnipotent, to conceive, that a globe, like the sun, considered to be equal to 354,936 earths, should be fitted to be the abode of rational and animal existences; while, at the same time, it dispenses LIGHT and HEAT to all around it from its *luminiferous atmosphere*, which may be considered the deepest and densest of any of the whole system, than to suppose, that such an enormous mass of matter is maintained, in an incandescent state, merely to supply the planetary orbs with light and heat! Further, it ought not to be overlooked, that the inspired historian alludes to the placing of those lights in the heavens *after* the formation of our firmament; and there is nothing to lead us to imagine that what was taking place on the earth was not *simultaneously* taking place on the sun

* The Mosaic account, however, is very simple and plain. Darkness and attraction are synonymes. The sun is and always was, in our system, the centre of this influence. On the formation of the primary light, the sun (in common with the other orbs), was caused to rotate, and judging from analogy, had an atmosphere, commensurate to its own magnitude, conferred upon it. Subsequently, or, on the fourth day, the remainder of the primary light was concentrated around the sun, the centre of attraction, and consequently around its proper atmosphere; and from thenceforward, by means of the voltaic currents which this occasioned, it dispenses light and heat to all the others of the system.—AUTHOR.

and other spheres of the system. There is, therefore, it is conceived, in this remarkable coincidence of time, an additional evidence in support of the position so resolutely assumed. Full conviction in favour of the assumption, will fall with greater force on the mind when it is considered, that the idea, on the other part, of *the sun being an incandescent mass of matter sending forth luminous rays*, although apparently in accordance with some of the more common phenomena exhibited by ignited bodies; so far from enabling us to explain the nature of the light and heat which are communicated to us by that luminary, rather adds to the difficulty in a philosophical point of view; because, as has already been shown, so long as a single mass of granite is found perforating the stratified materials of the earth's crust, so long must it be admitted as a true and clear deduction therefrom, that unless the common centre of gravity of the solar system had been changed in the act of illuminating the sun, no additional matter causing gravitation could, with safety to the entire solar economy, have been added to that central body. LIGHT is the only thing known which possesses *no gravity*.* While, as the electrical influence residing in material bodies circulates at small appreciable depths beneath the surface,† it follows, that the rays would have possessed polarity had they proceeded in a certain direction from a material body incandescent itself by electrical agency.‡ But as they do not possess polarity, then they must reside, as supposed above, in the surrounding atmosphere, or, in other words, in the firmament of heaven, which, at the period mentioned, was caused to dispense luminous rays.

Without any intention to detract, in the slightest degree, from the vastness and grandeur of our conceptions of that Almighty power which could thus, at will, concentrate the newly-created principle of expansion around the central orb of this system; and as assuredly around the focal orb of every other distinct system—and these conceptions will not be complete in their vastness, unless it be considered, that the principle alluded to, was, by its nature, disposed to expand—yet the present opportunity cannot be allowed to pass without reverting, by connexion of ideas, to these interesting experiments in natural philosophy, already alluded to, during which the non-luminous voltaic currents, which had been streaming unobserved by the eye along the conducting wires; and, at the will of the operator, caused to produce many wonderful transformations and effects, are, of a sudden, brought together upon some interposed body, and made thereby to send forth the most intense rays of light and heat.§ When it is considered, that whatever *now* occurs takes place because *it was then instituted*, that *it flows from laws then established*, we cannot fail to imagine, that in this comparatively puny exhibition, shewing the diversified power of voltaic electricity, we

* Theorem 46. † Theorem 60. ‡ Theorem 42. § Theorem 61.

behold a faint, faint indeed, yet kindred result to that which was exhibited on the *fourth* day of the Mosaic week.

It may be considered, that when the Creator of the universe had —by the application, in separate and divided streams of darkness, and of the newly-formed principle of expansion—brought into existence those successive changes which were considered necessary on the fourth day, He bent the great stream of light in upon the central orb, and immediately its firmament or atmosphere became the radiating source of light and heat to all those planets, which before had hung upon it as the pivot of their dark orbital course through space; *and that, ever afterwards, the two great principles of attraction and expansion travelled in parallel lines, but in opposite directions.*

During the delightful contemplation we have thus been privileged to enjoy, in beholding this amazing union of simplicity and power, we have not dwelt sufficiently upon the conception of the sun having been, during the non-rotary period, the centre of *darkness* or *attraction*, and, that it is the same still; whilst the state or condition conferred upon the *primary light* was that of *expansion.* The juxta-position in the mind of these conceptions tends wonderfully to augment our impressions of the *power* and the *wisdom* of the Creator, who could thus, at will, constrain that which of all other elements was the least disposed to condensation—the expansive principle of light—to concentrate itself around a centre, and more so still, when it is considered, that that point was the centre of *attraction!* That the source of *light* should also be the centre of *darkness* makes manifest the consummate wisdom of God! *There* it is that *attraction*, in our system, is at its maximum, and *there*, consequently, its restraining power can be most influentially exercised in maintaining the element of expansion precisely where it is least disposed, by its innate nature, to reside. Whilst the *body* of the sun, being the darkest point in the economy of the heavens, can best resist the approximation of the mass of light and heat which has been placed around it!

In a former part of this work, the identity of electricity and light was made manifest; and, while I beg to refer to what has been said, before proceeding to the consideration of any other connected branch, I shall now follow up what was then done, by endeavouring to exhibit the intimacy which exists among the various kinds of electricity themselves; next, that prevailing between electricity and magnetism; then the magnetic currents which flow round the earth; and in conclusion, of this branch of the subject, allude to the ascertained phenomena which link them all closely together into one grand and uniform whole, indicative of their common origin. The *fifty-ninth* Theorem states—"*That* ELECTRICITY *is a physical agent, possessing the properties of a self-expansive fluid, ... and, that although several varieties of electricity are known to exist, de-*

pendent on the manner in which the electric force is excited, yet they are sufficiently related to one another to justify the conclusion, that they all originate from a common principle, and are the effects of one individual power." The data which substantiate these assertions will be found detailed in the following extracts :—

"What electricity is," observes Dr. Thomson, "we know not. It is familiar to us only in its effects. We are ignorant whether it is a subtile matter of independent existence, or merely a new arrangement of molecules; nevertheless, we speak of it as material, and call it the *electric fluid* or *electricity*. Numerous as crude were the theories of philosophers before the hypothesis of Franklin was promulgated. While he considered that it pervaded creation, he was disposed to think that friction changed its normal condition in bodies; hence arose the divisions, *plus* or *positive*, and *minus* or *negative* electricities. Æpinus, Cavendish, and Van Marum, did much to further the views of Franklin. Peltier has proposed a theory which intimately connects the phenomena of electricity with those of light and heat, upon the undulatory hypothesis of these fluids. The *static* phenomena he supposes to result from an undue proportion of electricity; the *dynamic* to the re-establishment of electrical equilibrium between bodies unequally charged, by means of vibrations of this *electric ether*. Becquerel leans to the undulatory theory of this fluid, and the discoveries of Faraday point strongly to such a conclusion. . . . . .

"That lightning and electricity are *one*, is now firmly believed. The first suggestion of their identity is due to Stephen Gray, a pensioner of the Charter House, and Fellow of the Royal Society, &c. &c.

"Romas in France, and MM. Becquerel and Breschet on the Great St. Bernard, have performed the experiments of drawing electricity from the atmosphere. Mr. Crosse, of Bromfield, near Taunton, and Mr. Weekes, of Sandwich, have erected suitable means for collecting this fluid from the same source.

"By an ingenious adaptation of a modification of *Volta's eudiometer*, the latter has been able to show, through its agency, the alternate and almost momentary analysis and synthesis of water. . . . . .

"The identity of atmospheric and machine electricity has been further proved by the application of the former to electrolysis. . . . . . . Since then chemical compounds have been frequently decomposed by Crosse and Weekes by means of their operative media; and the latter gentleman has farther demonstrated the identity of these electric fluids, by rendering iron powerfully magnetic, by placing steel bars longitudinally within a helix connected with the exploring wire of the apparatus.

"Since the experimental proof of the unity of lightning and electricity, philosophers have pursued the enquiry still farther with the design of identifying the latter with light and caloric.

"The discoveries of Oersted, Seebeck, and Faraday, show an intimate connection. The last named chemist has very recently announced another brilliant discovery, which we shall merely enunciate, that a ray of light may be electrified and magnetized, and that magnetic lines of force may be rendered luminous. The experiments of Faraday have established a true, direct relation and dependence between light and the magnetic and electric forces; and thus a great addition has been made to the facts and considera-

tions which tend to prove, that all these natural forces are tied together, and *have one common origin*."*

Mrs. Somerville affords us the following evidence to the same effect:—

"In the brief sketch which has been given," she observes, "of the five kinds of electricity, those points of resemblance have been brought forward which are characteristic of one individual power. But as many anomalies have lately been removed, and the identity of the different kinds placed beyond a doubt, by Dr. Faraday, it may be satisfactory to take a summary view of the various coincidences in their modes of action on which their identity has been so ably and so completely established by that great electrician.

"The points of comparison are attraction and repulsion at sensible distances, discharge from points through air, the heating power, magnetic influence, chemical decomposition, action on the human frame, and, lastly, the spark," and so forth.

"Indeed, the conclusion drawn by Dr. Faraday is, that the five kinds of electricity are identical, and that the differences of intensity and quantity are quite sufficient to account for what were supposed to be their distinctive qualities. He has given still greater assurance of their identity by showing, that the magnetic force and the chemical action of electricity are in direct proportion to the absolute quantity of the fluid which passes through the galvanometer, whatever its intensity may be."†

Quoting again from that inexhaustible compendium, the Encyclopædia Britannica, we are informed, that—

"In the progress of his electrical researches, Dr. Faraday found it necessary, for their further prosecution, to establish either the identity or the distinction of the electricities excited by different means; and in a paper of great value, he has established, beyond a doubt, the identity of common electricity, voltaic electricity, magneto-electricity, thermo-electricity, and animal electricity. The phenomena exhibited in these five kinds of electricity do not differ in kind, but merely in degree; *and in this respect they vary in proportion to the variable circumstances of quantity and intensity, which can at pleasure be made to change in almost any one of the kinds of electricity, as much as it does between one kind and another*."‡

These concurring evidences ought to be quite conclusive as to the point sought to be established—the community of principle pervading the several varieties of electricity; but should further proof be considered requisite, the numerous other authorities, on this favourite science may be consulted, with the assurance, that a similar conclusion will be come to.

According to the plan laid down I shall now proceed to enquire into the intimacy which exists between electricity and magnetism. With this design let us, in the first place, refer to the *sixty-second*

* Introduction to Meteorology, pp. 271—278, based on the authority of the Philosophical Magazine, 1845, 1846; Athenæum, No. 953; Philosophical Transactions, 1846; Quarterly Review, clvii.; Silliman's Journal, May, 1846, No. iii.; Pouillet—Mem. de l' Inst., No. 630,

† Connection of the Sciences, pp. 352, 354.

‡ Article Electricity, p. 574.

Theorem :—" *That there is a strong analogy between* MAGNETISM *and* ELECTRICITY. *The agency of attraction and repulsion is common to both, and subject in them to the same laws; their intensities varying inversely, as the square of the distance between the bodies affected by them. That a like analogy extends to magnetic and electrical induction. And that there is such a perfect correspondence between the theories of magnetic attraction and repulsion, and electro-dynamic forces in conducting bodies, that they not only are the same in principle, but are determined by the same formulæ. While experiment concurs with theory in proving that, with the exception of electrical transference, the identity of these two unseen influences is complete.*"

I proceed at once, in continuation, to recapitulate the *sixty-fourth* Theorem, as being intimately connected with the one just given, "*That the magnetic action has a circular motion round the connecting wire of a voltaic current, whose course, always constant with respect to each of the poles of a magnet, is similar to the direction of the earth and other planets around the* SUN, *and about their respective axis.*"

It will, no doubt, have been observed, that, in giving the evidences respecting the several varieties of electricity, and the intimacy which subsists between them and light, it has been unavoidable to give several passages strongly confirmatory of the assumptions laid down in the two foregoing theorems; a circumstance which, though it will at present restrict us to a few concise quotations, is of itself one of the best proofs which can be adduced of the similarity existing in general, amongst all the ramifications of the EXPANSIVE PRINCIPLE, which sends forth, as it were, these various modifications of its power according to the attendant circumstances :—

"From the law of action and reaction being equal and contrary," Mrs. Somerville observes, "it might have been expected, that as electricity powerfully affects magnets, so, conversely, magnetism ought to produce electrical phenomena.

"By proving this very important fact from a series of interesting and ingenious experiments, Dr. Faraday has added another branch to the science, which he has named magneto-electricity. . . . . .

"By these manipulations it has been shown, that magnets produce the very same effect on the galvanometer that electricity does; though at the time no chemical decomposition was effected by the momentary currents which emanate from magnets, they agitated the limbs of a frog; and Dr. Faraday justly observes, that an agent which is conducted along metallic wires in the manner described, which, while so passing, possesses the peculiar magnetic actions, and force of a current of electricity, which can agitate and convulse the limbs of a frog, and which, finally, can produce a spark by its discharge through charcoal, can only be electricity. . . . . .

"After Dr. Faraday had proved the identity of the magnetic and electric fluids by producing the spark, heating metallic wires, and accomplishing chemical decomposition, it was easy to increase those effects by more powerful magnets and other arrangements.

"The apparatus now in use, is, in effect a battery, in which the agent is the *magnetic* instead of the *voltaic* fluid, or, in other words, electricity."*

"It is to Dr. Faraday," observe the compilers of the Encyclopædia Britannica, "that we owe a complete analysis and explanation of the curious phenomena of rotation of a magnetical needle round an electrical current, and of a body transmitting an electrical current round a magnet, &c.

"This explanation was founded on the great discovery of the evolution of electricity from magnetism, by which Dr. Faraday laid the foundation of the new science of magneto-electricity. By means of a series of simple and beautiful experiments, ... he has clearly established the laws according to which a magnet developes magnetic currents. Dr. Faraday also applies these laws to the explanation of the reciprocal action of revolving magnets and metals, and he adduces unquestionable proofs of the production of electricity by terrestrial magnetism.

"These important results have been more recently extended by him and others. M. Pixii observed attractions and repulsions in the electricity evolved by magneto-electric induction; and by an ingenious and powerful apparatus he obtained a great degree of divergence in the gold leaves of an electrometer.

"At the meeting of the British Association, at Oxford, in June, 1832, Dr. Faraday, by means of Mr. Snow Harris's electrometer, succeeded in heating a wire by magneto-electric induction.

"By means of the magneto-electric apparatus of M. Pixii, already referred to, he and Mr. Hachette decomposed water, and obtained the oxygen and hydrogen in separate tubes."

And a little further on they add—

"Before we close this brief history of electrical discoveries, we must notice the very remarkable one by M. Peltier, 1833, who has announced, that without changing the producing cause, he can transform *quantity* of electricity into *intensity*, and *intensity* into *quantity*, and neutralize two similar currents, proceeding from the same cause, by making them interfere in opposite directions."†

The perusal of these theorems, with their corresponding evidences, brings us to the penultimate point which is to be examined in elucidation of this particular branch of the enquiry, namely, the magnetic currents which flow round the earth. Let us begin by considering what is stated in part of the *sixty-fourth* Theorem, "*That currents of electricity analogous to these are constantly flowing round the earth, at right angles to the magnetic meridian. And by some it is considered, that the arrangement of the materials composing the outer crust of the globe may be such as to constitute a voltaic girdle, sufficient, though of feeble electric powers, to produce terrestrial magnetism.*" Aud, in continuation, recapitulate the concluding part of the *sixty-fifth* Theorem, "*That the laws of* TERRESTRIAL MAGNETISM, *although inconsistent with those which belong to a permanent magnet,*

* Connexion of the Sciences, pp. 338—340. A perusal of the entire passage, too long for insertion here, is strongly recommended.—AUTHOR.

† Article Electricity, pp. 574, 575.

are perfectly accordant with the conditions peculiar to a body in a state of transient magnetic induction."

Before giving the quotations which support these theorems, I would take occasion to direct the attention to the important bearing which the announcements—made by some of those who have studied the subject—have upon the leading features of this theory; these conclusions, themselves, arising from the discoveries recently made of the more recondite laws of the subtile magnetic fluid. It is asserted by them, "that the stratified masses, which constitute the major part of the earth's outer crust, may be considered as a battery existing like a girdle around the globe, which assists to produce terrestrial magnetism, and as the channel of its currents."

When the intimate connection which subsists between *light* and these *magnetic currents* is considered, we must be convinced that there also exists as real a connection between the TIMES of the formation of the stratified mass and of the introduction of the light; both being in accordance with the principles herein laid down. The stratified girdle required to be *first* formed, not only that it might lend its powerful aid to overcome the inertia of a world, at rest, without rotation; but that it should for ever thereafter be the channel through which the subtile streams of electricity might silently and unobtrusively circulate in beneficent and life-sustaining currents over all its habitable surface. To be more fully persuaded of this we have only to imagine, if we can, a reverse order in the leading events of the creation—the light *first*, the stratified girdle *not* yet formed—and we shall catch a fearful glimpse of the confusion and devastation which must, in that case, have run riot, in place of the order and harmony which now prevail; and of the fostering influences which result now from these currents, which quicken and sustain every plant whose seeds and roots are embedded in the terrestrial zone through which they flow; the vegetable kingdom most probably, not being the only one sustained in vigour and healthfulness by them.

With these remarks I have much pleasure in giving the following confirmatory passages. Mrs. Somerville supplies the first:—

"The magnetism of the earth extends over every part of its surface," she observes, "but its action on the magnetic needle determines the poles of this great magnet, which by no means coincide with the poles of the earth's rotation."*

"In consequence of their attraction and repulsion, a needle freely suspended only remains in equilibrio when in the magnetic meridian, that is,

* Neither should they, according to the Dynamical Theory. The poles of rotation were determined by the direction in which the primary light affected the earth and caused diurnal motion. The poles of terrestrial magnetism arise from the light as now concentrated around the sun, and the earth's rotation. Consequently, as the centre of the originating cause was intermediately changed (that is, on the *fourth day*), so ought there to be a divergency between the poles of rotation and those of terrestrial magnetism.—AUTHOR.

in the plane which passes through a north and a south magnetic pole. There are places where the magnetic meridian coincides with the terrestrial meridian. In these a magnetic needle, freely suspended, points to the true north; but, if it be carried successively to different places on the earth's surface, its direction will deviate sometimes to the east and sometimes to the west of north. Lines drawn on the globe, through all the places where the needle points due north and south, are called lines of no variation. . . . . .

"The law of terrestrial magnetism is very complicated, and the existence of two magnetic poles in each hemisphere is more than probable. . . . . .

"The translation of the magnetic equator, the motion of the magnetic poles, the changes in the intensity of the magnetic force, and the variations of the dipping needle and the mariner's compass, have been ascribed to the heat of the sun; and Mr. Hansteen has even found a general resemblance between the isothermal lines and the lines of equal dip on the surface of the earth; yet in the present state of our knowledge they can only be regarded as effects of some unknown cause, and so much uncertainty prevails in the magnetic phenomena of the earth, that the results already obtained require to be continually corrected by new observations."

Further on Mrs. Somerville continues—

"Mr. Barlow has investigated this subject with much skill and success. He first proved, that the magnetic power of an iron sphere resides in its surface; he then enquired what the superficial action of an iron sphere in a state of transient magnetic induction, on a magnetized needle would be, if insulated from the influence of terrestrial magnetism. The results obtained, corroborated by the profound analyses of M. Poisson, on the hypothesis of the two poles being indefinitely near the centre of the sphere, are identical with those obtained by M. Biot for the earth from M. de Humboldt's observations. Whence it follows that the laws of terrestrial magnetism deduced from the formulæ of M. Biot, are inconsistent with those which belong to a permanent magnet, but that they are perfectly concordant with those belonging to a body in a state of transient magnetic induction. The earth, therefore, is to be considered as only transiently magnetic by induction, and not a real magnet. Mr. Barlow has rendered this extremely probable by forming a wooden globe, with grooves admitting of a copper wire being coiled round it, parallel to the equator, from pole to pole. When a current of electricity was sent through the wires, a magnetic needle suspended above the globe, and neutralized, from the influence of the earth's magnetism, exhibited all the phenomena of the dipping and variation needles, according to its position with regard to the wooden globe."

Finally, from this writer:—

"It is moreover probable, that terrestrial magnetism may be owing, in a certain extent, to the earth's rotation. Dr. Faraday has proved that all the phenomena of revolving plates may be produced by the inductive action of the earth's magnetism alone. . . . . . From his experiments, and also from theory, it is possible that the rotation of the earth may produce electrical currents in its own mass. In that case they would flow superficially in the meridian, and if collectors could be applied to the equator and poles, negative electricity would be collected at the equator and positive at the

poles; but without something equivalent to conductors to complete the circuit, these currents could not exist."*

The compilers of the Encyclopædia Britannica confirm what has now been given on this subject, when towards the close of their circumstantial and elaborate article on terrestrial magnetism, they sum up, as it were, by observing:—

"In the progress of discovery it has been found, that the phenomena of the dip and the variation are more complex than the previous hypothesis will allow us to suppose; and in measuring the magnetic intensity in Siberia, M. Hansteen has proved that there is another magnetic pole in that country, which regulates the magnetic phenomena. In order to account for these, we must, therefore, suppose another magnet passing through the globe in the direction of a diameter whose pole coincides with the Siberian magnetic pole.

"A more sober and philosophical hypothesis is one which has long been gaining ground, and which recent discoveries have rendered still more probable. According to this hypothesis, the magnetism of the earth is not that of a magnet, but that of a sphere or spherical shell of iron on which magnetism is induced. The difference between these two magnetic states is very great. In regular magnets the centres of action are placed at their extremities or poles; but in masses of iron, either hollow or solid, either regular or irregular, the centres of action are always coincident with the centre of attraction of the surface of the mass. When the observations on the variation and dip of the needle became numerous and accurate, philosophers soon perceived that they could not be explained by the action of the two magnetic poles at a distance from each other. M. Biot had the merit of first viewing the subject in this light, and he, at length, came to the conclusion, that the nearer the poles were taken to each other, the greater was the agreement between the computed and observed results; and, by assuming the two centres as indefinitely near to each other in the centre of the earth, the coincidence between observation and calculation was as great as could be expected. Now it is a remarkable fact, that Mr. Barlow discovered, as we have already seen, that such a coincidence in the centres of action actually takes place in all bodies which are magnetised by induction, such as iron spheres or shells; and he has applied the principle to account for the various phenomena of the dip and variation of the needle. Almost all philosophers who have since investigated the subject have adopted the same idea, and the only difficulty which now attaches to it is, where to find the cause by which the earth's magnetism is induced. The following speculations on this curious subject are hazarded by M. Hansteen in his work on the magnetism of the earth:—

"'For these reasons, it appears,' he observes, 'most natural to seek their origin in the sun, the source of all living activity; and our conjecture gains prababilty from the preceding remarks on the daily oscillations of the needle. Upon this principle the sun may be considered as possessing one or more magnetic axes, which, by distributing the force, occasion a magnetic difference in the earth, in the moon, and in all those planets whose internal structure admits of such a difference; yet, allowing all this, the main difficulty seems not to be overcome, but merely removed from the eyes

* Connexion of the Sciences, pp. 315, 349—351.

to a greater distance; for the question may still be asked with equal justice, *Whence did the sun acquire its magnetic force?* And if from the sun we have recourse to a central sun, and from that again to a general magnetic direction throughout the universe, having the milky way for its equator, we but lengthen an unrestricted chain, every link of which hangs on the preceding link, no one of them on a point of support.' "*

He then states, at greater length than can be transcribed into these pages, the most admissible mode of representing the subject, in his opinion, and proceeds, by saying—

"I reckon it possible, therefore, that by means of the mutual relations subsisting between the sun and all the planets, as well as between the latter and their satellites, a magnetic action may be excited in every one of those globes whose material structure admits of it, in a direction depending on the position of the rotatory axes with regard to the plane of the orbit. Each of the planets might thus give rise to a particular magnetic axis in the sun; but as their orbits make only small angles with the sun's equator and each other, these magnetic axes would, perhaps, on the whole, correspond with the several rotatory axes. . . . . The conical motions by which the rotatory axes of the planets are carried round the pole of the ecliptic (the precession in the earth) joined to the revolving motion of the orbits about the sun's equator (which occasions the present diminution in the obliquity of the ecliptic) might perhaps, in this case, account for the change in the position in the magnetic axis.

"Such," resume the compilers, "was the state of speculation on this part of the subject, when M. Hansteen published his work on the magnetism of the earth. The poles of our globe were then regarded as the coldest parts on its surface; and no conjecture ever had been hazarded regarding the connexion between the phenomena of terrestrial temperature and terrestrial magnetism, till Sir David Brewster proved, from an immense number of meteorological observations, that there were in the northern hemisphere two poles of maximum cold; that these poles coincided with the magnetic poles; that the circle of maximum heat, like the magnetic equator, did not coincide with the equinoctial line; that the isothermal lines, and the lines of equal magnetic intensity, had the same general form surrounding and enclosing the magnetic poles and those of maximum cold; and that by the same formulæ, *mutatis mutandis,* we could calculate the temperature and the magnetic intensity of any point of the globe."†

In fulfilment of the proposed plan, for the investigation of this particular branch of the subject, there requires only to be summed up what has been said, by exhibiting, as closely as possible, the intimate relationship which subsists between what may with probability be considered mere varieties of one great and comprehensive power. The *sixty-sixth* Theorem, which has reference to this point, states:— "*That in light, heat, electricity, and magnetism, principles are exhibited*

* If M. Hansteen would but consent, his scientific and enquiring mind would be brought to rest, by belief in the sublime truths enunciated thousands of years ago, that, "God said, Let there be Light." And again, "God set them in the firmament of heaven." Genesis i. 3, 15.

† Magnetism, pp. 750, 751. The reader is recommended to peruse, if convenient, the whole of this most elaborate and circumstantial article.—Author.

which, although they do not occasion any appreciable change in the weight of bodies, manifest their presence by the most remarkable mechanical and chemical effects. And that these agencies are so connected as to afford every reason to believe they will ultimately be referred to some one power of higher order, in conformity with the general economy of the system of the world; in which the most varied and complicated effects are produced by a small number of comprehensive laws."

In elucidation of this propositional method of stating these truths, and while consideration is had to the recent frequent allusions already made to the intimate relationship which subsists between these kindred branches of the expansive principle, I shall take occasion to give only one quotation, which forms also a brief summary of Mrs. Somerville's observations on the same subject:—

"In light, heat, and electricity or magnetism," she observes, "nature has exhibited principles which do not occasion any appreciable change in the weight of the bodies, although their presence is manifested by the most remarkable mechanical and chemical action. These agencies are so connected, that there is reason to believe they will ultimately be referred to some one power of a higher order, in conformity with the general economy of the system of the world, where the most varied and complicated effects are produced by a small number of universal laws. These principles permeate matter in all directions; their velocity is prodigious, and their intensity varies inversely as the square of the distance. The development of electric currents, as well by magnetic as by electric induction, the similarity in the mode of action, but, above all, the production of the spark from a magnet, the ignition of metallic wires, and chemical decomposition, show that magnetism can no longer be regarded as a separate, independent principle. That light is visible heat seems highly probable; and although the evolution of light and heat during the passage of the electric fluid may arise from the compression of the air, yet the development of electricity by heat, the influence of heat on magnetic bodies, and that of light on the vibrations of the compass, show an occult connexion between all those agents which probably will one day be revealed. In the meantime it opens a noble field of experimental research to philosophers of the present, perhaps of future ages."*

These diversified investigations, which have occupied the attention almost exclusively since the commencement of this section, have been absolutely necessary, in order to show, in the first place, that the light could *not* have been concentrated around the sun during the period when those works of the Creator, which are recorded in verses 3 to 13 of the first chapter of Genesis, were in process. In the next, that it is *only from Scripture* that any information can be derived of the means and the power by which the light, after it had performed these works, was concentrated around the central orb of the planetary system. Again, that when the darkened nucleus of the sun was thus illumined, no matter possessing gravity was added to it. And, ultimately, that the light

* Connexion of the Sciences, p. 355.

which radiates from the sun, does not proceed from it as from an incandescent body, but from a circumfluent luminiferous atmosphere, in strict conformity with the spirit, and it might be added, with the very words of the announcement of Scripture, made upwards of thirty-two centuries ago—"Let there be luminaries in the firmament of the heaven." The perfect harmony which is thus shown to exist between those various points—where exceptions even render the coincidence more complete—ought to occasion a thorough conviction of the truth of the inspired narrative. Indeed, it is hard to conjecture what degree of coincidence will be sufficient to carry perfect conviction to the mind, if the evidences, which have been brought forward, do not produce this desirable result.

SECTION VIII.

CONCENTRATION OF THE LIGHT AROUND THE SUN; AND THE COMPLETION OF THE WORK OF CREATION.

CHAPTER XL.

The subject, of a change in the direction of the primary light, continued. Applied to the truths previously elucidated, and deductions drawn in favour of a by-gone period of non-rotation. Confirmatory conclusion deduced from the fact, that the illumination of the sun was the final coincident cause of the commencement of "signs, seasons, days, and years." Astronomical explanation of the vicissitudes of season. Application of the uranographical phenomena to the point under discussion. Concluding testimony: that which is borne to the correctness of this hypothesis by the creation, at this particular juncture, of the several races of animated beings which are dependent alike for motion and existence on atmospheric air. Termination of the evidences in favour of the Dynamical Theory.

THIS chapter will commence with the consideration of a resultant consequence of what has been so clearly made out, and has occupied the attention so much in former divisions; the perfect parallelism in which the influences of attraction and expansion, or of darkness and light, proceed *from* a centre and *towards* a centre, will be viewed together with some of those facts which have been previously established, namely, that the *direction* of the force of gravity has ever been invariable; that light proceeds in straight lines; and that it did *not* occupy its present centre, around the sun, during the first three days of the Mosaic week.

The blending of the former truth, the parallelism of light and darkness, with the three latter ones, leads to the conclusion, that as the direction of gravitation has *ever been* from the periphery *towards* and *through* the sun as a centre, and as the rays of light, in coming *from* their present centre, travel in a parallel direction to the others,* *this could not have been the case when the light was not situated where it is at present;* because that which "travels in

* See 43rd Theorem. By this it is merely meant to express the conception, that the general course of the undulations of a ray of light will be a straight line from the luminary causing it.—AUTHOR.

straight lines" could not have proceeded from any *two distinct points to the circumference by the same path;* therefore, as they *now* run parallel to each other, and one of them has been *invariable,* they must *formerly* have crossed each other with an obliquity commensurate to the obliquity of their respective centres of convergency and divergency; again, as dissimilar causes cannot produce similar effects, and it has been laid down, as a fundamental principle of this Theory, that the words of the first chapter of Genesis form *the constitutional code of all materialism,* it should result, as a necessary consequence of these premises, that on the light having been concentrated around the sun, on the fourth day of the Mosaic week, it must have undergone a very important change of character, corresponding to the change of *relative* position from obliquity to parallelism; admitting this change of character, which cannot be denied, the *necessity is perceived for the command which re-endowed it with powers, which it could not have had, in consequence of the change which took place in itself,* unless we should permit ourselves to suppose that *two distinct* causes are capable of producing the *same* effect. Nor should we pass on from the contemplation of this great truth without sufficiently bringing to mind the all-important difference in the effects which would flow from this relative difference in the direction of these two potent and almost omnipresent forces. This subject is well deserving of every consideration, and of being wrought out with much more care and attention than the limits and plan of this work will permit. Nevertheless, what has been advanced has clearly brought out the propriety, nay, the necessity, that the lights which were placed in the firmament of the heaven, should, by a special command, be made to "rule over the day and over the night, and divide the light from the darkness." Indeed, every step taken to scrutinize the more comprehensive laws which govern materialism, only shows, more convincingly, that the sacred historian precedes us; and has revealed, thousands of years ago, in the plainest and most concise terms, those very truths which appear to be but now unveiling themselves, to reward the industry and assiduous researches of modern philosophy!

But there is another and a very important inference which is to be drawn from the *divergency* of directions here alluded to; for LIGHT, which did *not* run parallel to DARKNESS, could not produce the *same* effects as that which does. This conception will strongly corroborate the assumption so frequently adopted and applied, namely, that the primary light, though perfect in itself, was not in every respect identical with that which now proceeds from the sun. It was light, but it was light in a different state, coming from a different source, and evidently running obliquely to the direction of *attraction.*

In prosecution of the general argument, I shall, next, proceed to a brief consideration of the indirect but peculiar bearing on the

leading hypothesis of this theory exercised by the remarkable announcement, that the sun, *by being illuminated on the fourth day of the Mosaic week*, became, to the earth, the cause of "signs, seasons, days, and years." The *putting of this command on record* nearly three thousand three hundred years ago, affords the most undeniable evidence that the recorder was an inspired amanuensis of the Deity. It may be well to observe, that as I am now dealing with a class of facts which occurred *after the earth had rotation impressed upon it,* and the source of whose influence is altogether exterior to it, they can only confirm this theory incidentally, or as far as they necessarily involve, in themselves, an undoubted foreknowledge of events proved by the dynamic system to have taken place previously, but which were wholly unknown to the world's inhabitants at the time when these announcements were put on record; while they shed back, by reflection, a convincing stream of evidence on what may have been assumed in reliance on these announcements, and on the validity of scientific discoveries and deductions. The present instance is one peculiarly in point. The evidence consists in the knowledge which the *ultimate writer* of that recorded fact possessed of the true motions of the heavenly bodies of the system. To the act of directly illuminating the sun and the moon indirectly, are ascribed results which, of necessity, involve one of the two following consequences: that the writer was aware that the earth was impressed with a double movement in space, one around the sun, and the other around its own axis; and also, that the moon circulated in its orbital course around the earth; and, with this knowledge, he ascribed *to the lighting up of the central orb, and to the reflection of its rays from the moon*, the causing of signs, seasons, days, and years, as these actually do; besides, he must have been aware of a still more recondite truth, which I trust presently to establish, namely, that the lighting up of the sun and the movements of the heavenly bodies, *could not have caused the vicissitudes of the seasons, unless the primeval light had once occupied a distinct centre, and put forth energies of a peculiar description.* This is one view of his position; the other is, he was entirely ignorant of these truths, and merely lent himself as an implicit but unconscious instrument to register what he did not himself comprehend. But whether we consider the writer to have stood in one or other of these positions, when all these points are duly weighed, it must appear evident to every candid and impartial mind, that even after awarding to eastern astronomy the utmost advance it can in justice lay claim to, the Jewish historian could not have been instructed in what he has recorded by any *merely human* intelligence; and, therefore, if, on the one hand he was aware of their full import, and understood what he wrote, he must have received that knowledge from a divine source; while, on the other hand, if he registered these sublime and recondite truths unconsciously, without understanding their meaning, he must likewise

have done so at the dictation of a spirit more than human; and, as that which he has recorded is *truth*, that spirit must have been the Spirit of Truth.

To make more palpably manifest the gross ignorance which long prevailed respecting the orbital motions of the heavenly bodies, and the reluctant incredulity evinced to believe in the true, the Copernican system, I give, without apology, the following extracts, as nothing could be better expressed or more appropriate:—

"It is seldom easy," observes Mr. Nichol, "to ascertain why or how a new truth is revealed, that majestic event usually occurring when old systems seemed to have reached their climax and achieved perfection. When, however, the still small voice comes it is one of dread. The accomplished part of the world feels as in an earthquake, although the deserts may rejoice at the rising light. The obscurity of the times in which Copernicus lived rests over his early character. We know not how far favourable circumstances contributed to the development of his genius; or whether, without peculiar advantages, he owes all to an inborn energy. But, whatever his mental culture, the greatness of his mind could be borrowed from no one; inasmuch as he was the earliest to accomplish a task most difficult for man. . . . . . He threw from him the weight of ages, and quietly asked whether that fundamental tenet, which asserts that the earth is motionless, might not be false.* The mental effort required, even to hesitate on a point which all mankind had up to that moment undoubtingly believed, and which had now interwoven itself with every mode of thought, was an achievement for the loftiest order of genius; the question once put, it required only superior but not uncommon talent, to follow it to its conclusions. . . . . . Modesty, a characteristic of the finest minds, induced Copernicus, after he had obtained sight of this great idea, to search through the ancient philosophies, lest there might be precious relics buried there, to confirm and encourage him; and accordingly he did find certain hints, touching on a simpler order of things, which his correct and discriminating intellect speedily methodized into that system which, in the somewhat hyperbolical language of his successor, Tycho, 'moved the earth from its foundations, stopped the revolution of the firmament, made the sun stand still, and subverted the whole ancient order of the universe.' . . . . Using the best means within his reach, he constructed a theory of the apparent motions of every planet; and the results corresponded so closely with observation, and offered so thorough an explanation, that nothing was left to his opponents but the interposition of mystical arguments. This illustrious man received the proof copy of his work on his death bed."†

Sir John Herschel, though in more general terms, bears testimony to the same facts, when he informs us that:—

"As the decisive mark of a great commencing change in the direction of the human faculties, astronomy, the only science in which the ancients had made any real progress, and ascended to anything like large and general

* "I have seen it stated," he adds in a foot note, "that Copernicus was a great man by accident—that he owes his name to a happy conjecture! Let the authors of this opinion review the whole history of mankind, and reckon the number of such happy conjectures!

† Contemplations of the Heavens, pp. 13, 14, 21.

conceptions, began once more to be studied in the best spirit of a candid philosophy; and the Copernican or Pythagorean system arose or revived, and rapidly gained advocates. Galileo at length appeared, and openly attacked and refuted the Aristotelian dogmas respecting motion, by direct appeal to the evidence of sense, and by experiments of the most convincing kind. The persecutions which such a step drew upon him, the record of his perseverance and sufferings, and the ultimate triumph of his opinions and reasonings, have been too lately and too well related by Mr. Drinkwater to require repetition here. By the discoveries of Copernicus, Kepler, and Galileo, the errors of the Aristotelian philosophy were effectually overturned on a plain appeal to the facts of nature; but it remained to show, on broad and general principles, how and why Aristotle was in the wrong, to set in evidence the peculiar weakness of the method of philosophizing, and to substitute in its place a stronger and better. This important task was executed by Francis Bacon, Lord Verulam, who will, therefore, justly be looked upon, in all future ages, as the great reformer of philosophy, though his own actual contributions to the stock of physical truths were small, and his ideas of particular points strongly tinctured with mistakes and errors, which were the fault rather of the general want of physical information of the age, than of any narrowness of view on his own part, and of this he was fully aware."*

It has been asserted in an immediately previous part of this work, that the illumination of the sun could not alone have caused it to produce the vicissitudes of seasons which are now experienced, unless the light had once occupied a distinct centre from that which it does at present. It shall now be my care to substantiate that assertion, by reference to the discoveries of modern science. Let us then, first of all, see what is stated in the *sixth* Theorem :—"*That the vicissitude of seasons experienced by the* EARTH *is owing to its globular form, the obliquity of the plane of the equator to that of the ecliptic, the parallelism of the earth's axis, and to the orbital motion of the earth around an illumined sun imparting light and heat.*"

The following are some of the evidences upon which this theorem is founded :—

Mrs. Somerville, in showing that the mean temperature of the earth has not varied, bears testimony to the invariable length of the *day*, by the following pointed expressions :—

"In consequence of the rotation of the earth being a measure of the periods of the celestial motions, it has been proved that, if the length of the day had decreased by the three-thousandth part of a second since the observations of Hipparchus, two thousand years ago, it would have diminished the secular equation of the moon by 4″ 4. It is therefore beyond a doubt that the mean temperature of the earth cannot have sensibly varied during that time."

While, as regards the stability of the seasons, the same writer gives forth as definite an opinion, thus :—

"The plane of the ecliptic itself," she observes, "though assumed to be

*** Discourse on Natural Philosophy, Cab. Cyc. pp. 113, 114.**

fixed at a given epoch for the convenience of astronomical computation, is subject to a minute secular variation of 45″ 7, occasioned by the reciprocal action of the planets. But, as this is also periodical, and cannot exceed 2° 42′, the terrestrial equator, which is inclined to it at an angle of about 23° 27′ 38″ 25, will never coincide with the plane of the ecliptic; so there never can be perpetual spring. The rotation of the earth is uniform; therefore day and night, summer and winter, will continue their vicissitudes while the system endures, or is undisturbed by foreign causes."*

"Henceforward, then," says Sir John Herschel, "in conformity with the Copernican view of our system, we must learn to look upon the sun as the comparatively motionless centre about which the earth performs an annual elliptic orbit, the sun occupying one of the foci of the ellipse, and from that station quietly disseminating on all sides its light and heat, while the earth, travelling round it, and presenting itself differently to it at different times of the year and day, passes through the varieties of day and night, summer and winter, which we enjoy. In this annual motion of the earth its axis preserves, at all times, the same direction as if the orbital movement had no existence; and is carried round parallel to itself, pointing always to the same vanishing point in the sphere of the fixed stars. This gives rise to the variety of seasons."†

I should regret to close these evidences and explanations of the seasons without giving the substance of Professor Nichol's very perspicuous *rationale* of them, and the very delightful inference which he draws from their existence:—

"The variation of the seasons," he observes, "which in the old astronomy, it required many fanciful and complex notions to account for, is owing to an extremely simple arrangement. . . . . . . It is obvious that if the terrestrial poles were perpendicular to its horizon there could be no seasons; for in whatever part of its annual orbit it might be found, the central luminary would shine over every part of it with the same relative intensity. . . . If, however, the axis leaned forward, or was inclined, the case would be wholly altered. . . . . . And if we suppose the axis to retain its position while the globe revolves in its orbital path, it is manifest that on reaching opposite sides of the sun, the southern and the northern hemisphere will be intensely heated in succession. Here, then, we have a change from summer to winter, and *vice versa;* and during the transition, the intermediate seasons of spring and autumn must have taken place. The change in question, then, is wholly owing to the inclined position of the globe's axis; and it must vary in degree with the amount of that inclination. Thus simple is the cause of such variations, and of all the exquisite adjustments with which they are connected. . . . . . .

"On matters of this kind men feel variously; I confess that to me the sight of such exquisite adaptation, which shows such precision of workmanship, and stedfast solemnity of march, is as strong and eloquent a proof of the presence of the Godhead, as those deviations from ordinary agencies, which in the course of providence the Almighty has thought proper to produce; and that with a far loftier and more intelligent ardour than that of

* Connexion of the Sciences, pp. 83, 27, 28.
† Astronomy, Cab. Cyc., American edition, pp. 185, 186.

the Egyptian magician, we may exclaim, as we humbly contemplate, THE FINGER OF GOD IS THERE."*

After the theorem and evidences now submitted have been attentively perused, I must recall to remembrance what was elucidated at great length, and with much care, namely, that the obliquity of the plane of the equator to that of the ecliptic—on which the vicissitudes of the seasons so essentially depend—originated from a very peculiar quality in the primeval light, previous to its being concentrated around the sun, and when it was supposed to have impinged in a direction perpendicular to the plane of the centre of gravity of our system; and from thence putting forth energies peculiar to itself and in connexion with influences on the earth, it generated a purely tangential force, *or rotation in planes at right angles to the line of its direction:* while it was, likewise, shown, that owing to the perfect equilibrium of the equipoising forces which maintained the earth in its orbital path around the sun, previous to its diurnal rotation (and which still retain it), it could have resisted no other force capable of overcoming its inertia, than the one thus wisely and wonderfully brought to act upon it in lines perpendicular to the axis of its diurnal rotation; and, certainly, when we are made thoroughly aware, that the obliquity of the two planes above mentioned, those of the equator and of the ecliptic, which proceeded from so recondite a cause, must have been known to the Jewish historian, at a time when all the nations around were in ignorance of this profound astronomical truth; and when we reflect, that the knowledge of a force, capable of producing motion at right angles to the line of its direction, has but lately dawned upon a surprised world, although both its existence and the first and most stupendous effects produced by it, are implied in the record made by the sacred historian, so many centuries ago, we must become convinced, more firmly than ever, *that in those writings only are to be found the base-lines of all real knowledge.*

Without dwelling longer on this point, I shall pass on to remark, more especially, that the narrator of the first chapter of Genesis, by the mere fact of having recorded that the lighting up of the central orb of our system should have been the ultimate immediate cause of "signs and seasons, days and years," makes known an implied knowledge *of the long continued non-rotation of the earth;* because, without including the *precession of the equinoxes,* which arose partly from the earth's protorotation, the comprehensive term of "seasons" cannot be considered complete; for, although the mutations occasioned by the *precession of the equinoxes,* are brought about in the course of many thousands of years,† yet they must have been as assuredly meant to have been classed amongst "the seasons," as

* Contemplations on the Solar System, pp. 208, 209.
† *Seventh* Theorem, to which please refer.

were the minute gradations which denote the diurnal progress of the sun's rays on the revolving earth. Astronomical writers assert, that the precession of the equinoxes is owing, amongst other causes, to the protuberance, or excess of matter, at the equatorial regions of the earth; for, says Sir John Herschel:—

"The immense distance of the planets compared with the size of the earth, and the smallness of their masses compared to that of the sun, puts their action out of the question in the enquiry of the cause, and we must, therefore, look to the massive though distant sun, and to our near though minute neighbour the moon, for an explanation of the precession of the equinoxes. This will, accordingly, be found in their disturbing action on the redundant matter accumulated on the equator of the earth, by which its figure is rendered spheroidal; combined with the earth's rotation on its axis."*

This excess of matter being wholly attributable to the condition of a sphere, which, after remaining for ages at rest, submerged in water, and having contracted repeated and numerous concentric layers of deposited matter encrusted around it, has been suddenly put into diurnal motion, I am authorized to conclude, from this closely-linked chain of reasoning, that whoever asserted, for the first time, that the lighting up of the sun, and the reflection of its rays from the moon, caused "signs, seasons, days, and years," must necessarily have been aware of the earth's previous state of non-rotation, this being clearly implied in the assertion, together with a knowledge of the actual rotatory motion of the earth, on which he dwelt while he penned the announcement in question. Thus it is evident that those astronomical laws, certain as they have since been proved to be, whose announcement drew down upon Copernicus the derision of his more prejudiced and ignorant comtemporaries, and the very truths for which Galileo, in later times, was accused before an odious tribunal, for which he was tried and condemned as an impugner of the word of God, are clearly and legibly stamped by the divine historian on the first of its sacred pages; and what may be considered still more remarkable, the same inspired author as clearly infers the more recondite, though no less certain fact, THAT FOR AGES PRIOR THERETO THE UNFORMED EARTH HAD NO ROTATION AROUND ITS AXIS.

I have thus endeavoured, by these continuous enquiries, to show the close connexion which, in essential particulars, subsists between the subtile influences light and heat, the points in which they seem to manifest themselves separately being as necessarily implied by this hypothesis. The intimacy between light, heat, and electricity has been exhibited, and that also which exists amongst the several kinds of this latter fluid. There has been made manifest the similarity of electricity and magnetism, and the reflex influence which they exercise on one another, and the great probability that

* Astronomy, Cab. Cyc., American edition, p. 309.

these, altogether, are modifications of the one comprehensive power, *expansion*, the all-pervading influence opposed to *attraction*. I have shown the need, according to the previously prevailing laws, of such a power as this having been introduced into materialism, at the critical juncture it is announced to have been, in order that it should, by overcoming the inertia of the earth and other spheres, cause them to rotate around their respective axis. I have striven to prove by the presence, on the one hand, of innumerable concentric layers of mineral matter around the exterior of the earth, which has been impressed with rotatory motion; and the absence, on the other hand, of these stratiform masses in the moon, which has not had diurnal movement communicated to it; that these concentric mineral encrustations, and also the saliferous waters in which they were immersed, were required as a commensurate leverage to produce diurnal rotation. While I beforehand took occasion to explain, how it was that these necessary stony concentric layers could alone have been formed by deposition at the bottom of a dark and atmosphereless ocean, unknown to rotatory influences, and inhabited by the classes of plants and animals which science and revelation concur in showing did there exist, and could alone have produced the rocky accumulations which are now so highly inclined and tilted up out of horizontality. And thus, link by link, as it were, the subject has been brought to a point which connects the whole with the first announcements of Scripture, that, "In the beginning God created the heavens and the earth," that "Darkness was upon the face of the deep, and the Spirit of God moved upon the face of the waters," during the protracted but indefinite period of non-rotation, and, as a necessary consequence, the mind has thus become prepared for the emphatic declaration which immediately follows:—

"God said, let there be light"—

Thus rendering all these investigations subservient to the elucidation of the leading doctrines of the Dynamical Theory, namely, assuming a condition of non-rotation, the introduction of the light caused diurnal motion, and subsequently all the phenomena resulting from it, and from the pre-arranged material elements; that it was God alone, who did all this; and that he has been pleased to reveal, for our information, the way in which these wonderful works were performed.

There remains, now, only one source of evidence *to corroborate the non-rotatory period of the earth's existence*, one apparently so disconnected, that were it not from reluctance to deprive any of the works of the Creator of its rightful share of the honour of supporting this fundamental truth, I would be inclined to pass it over altogether. I allude to the formation of those creatures of the animal kingdom which depend for their existence on the ethereal medium and on atmospheric air, and are fully *endowed with the faculty of locomotion*, whether their movements be restricted to the surface of the earth;

whether they roam throughout the waters of the ocean, or soar into the aerial regions of the atmosphere, *provided they possess the power of freely accelerating and retarding their own motions, and breathe atmospheric air.* To cause objects so widely apart and so dissimilar to become evidences, the one of the other, will demand some exercise of patience, and constrain us to run hastily through most of the intermediate links, in order to maintain that connexion which can alone carry conviction to the mind. In doing this, however, the attention given to a great many of them in the fields of enquiry over which we have already passed, will aid very materially; while, as an introduction to what I may now have occasion to state, it may be observed, that there is a remarkable difference between the *kind* of *light* employed to form the *animal* kingdom of locomotive faculties, and that which was used in constructing the *vegetable* existences. The light which was made to enter into the composition of the creatures of the fifth and sixth days, not only came from its present centre—the sun—but was made to pass through the seas and through the earth before it became embodied into animated existences. And in these respects it differed essentially from the light made use of during the first *three* days; and consequently must have produced different results, as far as it entered into the composition of the objects formed during these respective periods. The variation, no doubt, has some mysterious connexion with their living principle, or their power to overcome attraction or inertia at will.

The following is a concise definition of the species of locomotion to which I allude:—

"Locomotion," say MM. Todd and Bowman, "is that function by which an animal is able to transport itself from place to place. It is enjoyed exclusively by animals; there being nothing analogous to it in the vegetable kingdom. But even, among animals, there are exceptions to the existence of this function. Many of them are fixed in their places throughout their lives; others enjoy the power of locomotion for a short period, but subsequently become fixed; while others again begin life fixed to one place, and are, at length, set free."*

Having ascertained what that motion is, we must next become acquainted with the "intimate connexion which exists between the power of accelerating voluntary motion and the function of respiration, action of the lungs, and the circulation of the blood," which constitute the subjects of the *hundred and thirty-eighth* Theorem; and then look into some of the evidences on which that theorem is founded.

"We have just explained," says Baron Cuvier, "the several points on which all the vertebrated animals resemble each other. There are, however, certain differences which give rise to their separation into four large sub-divisions, or classes. These are characterized by the particular manner

* Anatomy of Man, by MM. Todd and Bowman, vol. i. p. 67.

in which their motions are performed, or by the degree of their energy or vigour, and these again depend upon the quantity of their respiration. The muscular fibres possess a greater or less degree of irritability and general energy according as the respiratory organs are more or less perfect.

"There are two conditions which determine the quantity of respiration. The first is, the relative quantity of blood supplied to the respiratory organs in a given time; and the second is, the relative quantity of oxygen, entering into the composition of the surrounding fluid. The quantity of blood purified by respiration depends upon the arrangement of the organs adapted for respiration and for circulation."*

Sir Charles Bell says—

"The function most essential to life is respiration; and the mode in which this is performed, that is to say, the manner in which the decarbonization of the blood is effected through its exposure to the atmosphere, produces a remarkable change in the whole framework of the animal body. Man, the mammalia, birds, reptiles, and fishes, have much of the mechanism of respiration in common; and there is a resemblance through them all, in the texture of the bones, in the action of the muscles, and in the arrangement of the nerves."

When treating of the circulation of the blood through the muscles, he says—

"There is one circumstance more which should not be omitted in the comparative anatomy of these muscles, as it exhibits another instance of conformity in their structure to the offices which they have to perform. We have just stated that the power of contraction is a vital property. The continued action of a muscle, therefore, exhausts the vitality; and to support that action, when it is inordinate, there must be a more than usual provision for the supply of this living power, viz., a means of increasing or maintaining the circulation of the blood, which is the source of all vital power."†

"The function of *respiration* in animals," say MM. Todd and Bowman, "is a very complex process, respecting the nature of which many unsatisfactory hypotheses had been formed. Until the law of the diffusion of gases, and of the permeability of membranes by them, had been developed, and until it had been shown that carbonic acid is held in solution in venous blood, no theory of respiration could be framed adequate to explain all the phenomena. It is now proved, that in this process, a true interchange of gases takes place through the coats of the pulmonary blood vessels, the oxygen of the air abstracting and occupying the place of the carbonic acid of the blood. . . . . . The presence of atmospheric air is necessary to the existence of all organized beings.‡ The air both passes by endosmoze into their nutritient fluids, and receives from them certain deleterious gases developed in their interior. The function by which the fluids are thus aerated is called *respiration*. . . . . .

"In animals, carbonic acid accumulates in the blood during its circulation; and when the atmosphere is brought to bear upon the capillary

* Edinburgh Journal of Natural History, p. 24.

† Bridgewater Treatise, pp. 19, 121.

‡ This must be taken with exceptions; for example, the animals and plants living and growing at the bottom of the ocean, indifferent as to voluntary motion.—AUTHOR.

vessels containing the blood charged with this gas, a mixture takes place through the delicate walls of the vessels, the atmospheric air passing in, and carbonic acid, with nitrogen and oxygen, in certain proportions, escaping. Thus, the evolution of carbonic acid, and the absorption of oxygen and nitrogen, are the characteristic features of respiration in animals."*

Dr. Thomson assures us, that—

"Without oxygen gas life could not be sustained. In it, unmixed with other gas, life flits away with greater rapidity than in common air; increased frequency of respiration is the immediate consequence, and disease of an inflammatory type follows, in consequence of the blood becoming more highly oxydized. (From Broughton—Quarterly Journal of Science, April, 1830). . . . . . According to Lavoisier and Seguin, an adult man consumes, by respiration in 24 hours, 46.037 cubic inches, or 32.5 ozs. of oxygen. Davy estimates the amount somewhat less, and Menzies slightly greater. . . . . . Boussingault (Annals de Chime) computes the consumption of oxygen by the horse in the same period at 13 lbs. 3 ozs., and by the cow at 11 lbs. 10.75 ozs., and so forth. . . . . . As we ascend, the atmosphere gradually decreases in density, and on lofty situations the effects of its rarity are disagreeably manifested. Acosta, in the 16th century, described the violent symptoms which he and his companions experienced on the mountains of Peru; and very recently Dr. J. J. Von Tchudi, on the Cordilleras. Baron Humboldt at an altitude of 16,000 feet felt overcome with fatigue, blood burst from his lips and ears, and respiration was affected. . . . . .

"The brothers Gerard, in their travels among the Himalehs, frequently felt the inconvenience of atmospheric rarity. One of them thus describes his feelings:—'Our elevation was now upwards of 15,000 feet; here only began our toils, and we scaled the slope of the mountain slowly; respiration was laborious, and we felt exhausted at every step. . . . . . Long before we got to the summit we were troubled with severe headaches, and our respiration became so hurried and oppressive, that we were compelled to sit down every few yards, and even then we could scarcely inhale a sufficient supply of air. The least motion was accompanied with extreme debility and a depression of spirits, and thus we laboured for two miles.' Lieut. Wood (Journey to Sources of the Oxus,) at the Bam-i-duniah, or '*roof of the world*,' perhaps the most lofty *plateau* on the globe, endeavouring to break the ice on the Lake of Sirikol, to measure its depth, found that a few strokes with the axe exhausted his men, and continued work was impracticable. Mr. Green, who in September, 1838, ascended in a balloon to the height of 27,136 feet, the greatest altitude yet attained, felt comparatively little inconvenience, although the first 11,000 feet were ascended in seven minutes. This arose evidently from the almost absolute repose of the body. Mr. Green felt his respiration hurried only when he exerted himself.

"Captain Batten says, 'the feelings experienced by him on the Nitlee Pass were far more severe than *Angina Pectoris*.' Moorcroft (Asiatic Researches), describing an exploring expedition among the Himalehs, says, that 'his breathing was quickened, and he was obliged to stop every four or five steps; he felt a sense of fulness in the head and giddiness.' . . . .

"Mr. Lyell tells us, that the English greyhounds, taken out for the

* Anatomy of Man, by MM. Todd and Bowman, vol. i. p. 3, 24.

Real del Monte Company, in Mexico, when hunting at an altitude of 9,000 feet, where the barometer does not rise above 19 inches, were unable to bear the fatigues of the chase, and fell down gasping in such an attenuated atmosphere."*

"Dr. Martin Barry has given the following account of his own feelings on ascending Mont Blanc. 'At an altitude between 12,000 and 14,700 feet he experienced great dryness, in some parts a lurid colour, and constriction of the skin, intense thirst, incipient loss of appetite; at 15,000 there was exhaustion and difficult breathing, coming on suddenly after 20 to 30 steps, up a plane of 30° of indurated snow, having a slippery surface; these effects passed off on standing still and taking a few deep inspirations.'"

And to conclude on this subject:—

"On climbing high mountains," says Baron Liebig, "where, in consequence of the respiration of a highly rarefied atmosphere, much less oxygen is conveyed to the blood, in equal times, than in the valleys or at the level of the sea, the change of material diminishes in the same ratio, and with it the amount of force available for mechanical purposes: for the most part, drowsiness and want of force for mechanical exertions come on; after every 20 or 30 steps fatigue compels us to a fresh accumulation of force by means of rest, absorption of oxygen without waste of force in voluntary motions."†

These ample and conclusive passages, supporting the theorem last mentioned, prove conjointly the indispensable necessity of atmospheric air for the perfecting of arterial blood, and the no less essentiality of this vital fluid for effecting voluntary motion; consequently the atmosphere was, and still is, absolutely necessary for the well-being, or even for the existence of all animals *possessing the power of movement at will;* for, as Sir Charles Bell emphatically expresses himself, in another part of the work already alluded to:—

"Any other hypothesis than that of the creation of animals suited to the successive changes in the organic matter of the globe, the condition of the water, atmosphere, and temperature, brings with it only an accumulation of difficulties."‡

In another part of this work it has been circumstantially proved, that the formation of the atmosphere depended upon the elaboration and evolution, during a succession of ages, of the constituent elemental principles, nitrogen or azote, and free oxygen; that these were produced by the decomposition of animal and vegetable substances submersed in water, which, in turn was employed as a great reservoir to retain them in a proper state of preservation, against the period when they should be required, in order to be transformed into their present state in the atmosphere, by combination with the subtile principle of expansion or light; whose existence in the then condition of our planet would have been inconsistent with the plan of the creation which was in progress of being developed; because

* The author has frequently witnessed similar results on other parts of the Mexican plateau.

† Introduction to Meteorology, pp. 8, 14, 16, 19, 20.

‡ Bridgewater Treatise, p. 149.

it was essential, that *throughout the whole surface* of the spherical, non-rotating world, depositions, layer after layer, from water, and encrustation on encrustation by animal agency and secretion, should have simultaneously taken place, before the sphere could be in a condition, not only to aid the impetus originating from the primary light, in overcoming the inertia of the globe itself, but also to be in a proper state to fulfil one of the chief objects designed by its rotation, namely, that the centrifugal impetus, engendered thereby, should have materials provided, which that protomotion was to elevate and to transform into the present diversified earth, a spacious and suitable habitation for the very animals whose creation was to follow, and which, at present, are brought forward as examples—the last group of evidences—to prove the once entirely different state of this very planet.

It has already been made manifest, that *wherever* organic remains are found, *there* life must, at one time, have existed. This axiom in natural history is so simple and so elementary, as scarcely to be worth insisting further upon; yet, rudimentary as it is, by its dexterous application, two very important truths are about to be substantiated, namely, that the fossilized remains of testacea and zoophyta, discoverable everywhere, and which abound throughout the mountains of the world, and on their highest ranges, could not have been brought into existence, at first, or afterwards have come to maturity, *unless they had been submerged in water*, and far less so had they been placed on those scarped summits, beyond the overflow of the ocean, and left without an atmosphere—if it were possible to conceive such a state of matters—on some arid peak, unsheltered from the sun's rays, even by the intervention of the aerial ocean which now floats over all. And again, that as the existence of the shelly coating, now petrified, but once a serviceable though inflexible covering, proves the previous existence of a fleshy animal within, but which no longer exists; it follows, as a clear deduction, that the fleshy molluscous portion must have undergone decomposition, separation into constituent elements, and exhalation, and that one of those elements must have been, and certainly was nitrogen or azote, an indispensable dilution in the atmosphere which now floats around and above, and which tends so materially, by the oxygen it contains, in conjunction with the azote, to the sustentation of animal life, by aerating the blood, which, in turn, is the mainspring of all voluntary motion.

Light, as already demonstrated, is as indispensable as any of those fundamental ingredients for the completion of the atmosphere. Without the addition of this buoyant principle to the other two more material ones, it could not have assumed its expansive condition; consequently it was as essential that, in due time, there should be light to combine with the bases, *nitrogen* and *oxygen*, as that there should have been those bases to combine with light, and,

by their union, to constitute the "firmament;" but protracted ages of darkness were essential for the elaboration of the elements, attenuated as they are, which constitute the light or ethereal fluid itself. It has also been shown that the introduction of light, or its completion, *before* the atmospheric principles had been stored up in the ancient ocean, before the primeval waters themselves had been properly purified, and the concentric stratified coatings of the spherical globe had been deposited and formed, would have been prejudicial to the plan of creation which was then in progress of being developed. That it was absolutely necessary, agreeably to the known constitutional laws which the Creator saw fit to impose on matter—that, for a lengthened period, this sphere should be submersed in oceanic waters, and kept in darkness and quiescence until all those wonders—which were each to assume its place in the composition of the perfect work—had been completed in the capacious womb of nature, and that not until then did it accord with His plans to complete, or to introduce physical light into the material universe. It must likewise be borne in mind, that another and very important means employed in forming the atmosphere, was the violent agitation in the primeval waters, induced by the centrifugal impetus, arising from the first rotation of the earth around its axis. Nothing short of a commotion so general and penetrating as this protomotion undoubtedly produced, and which seems to have been essential, could have been effectual in combining the atmospheric ponderable bases with the expansive principle of light; and it should therefore be understood, that in "stretching forth the firmament as a curtain," the Creator chose to employ the impetus arising from the protorotation of our sphere—which, up to this period had been encircled by a slumbering ocean, surcharged with gaseous elements—as one of the important agents which conspired to work out his design in this respect.

These conclusions show that the following indispensable requisites, agreeably to the established laws of matter, entered into the formation of the atmosphere, namely, oxygen, azote, light, and violent universal agitation.

It should, at the same time, be remembered, that, until the atmosphere had been formed, no animal existences *possessing the full power of locomotion* were willed into being; for, as has just been shown, this animal movement depends upon the circulation of the blood; which, in turn, is due to oxygenation by means of atmospheric elements. Here, then, we have the special conditions of the present subject, namely—free oxygen, azote, expansion, and violent agitation to constitute the atmosphere; and the recorded creation of innumerable tribes of animals *possessing the power of locomotion*.

If the four principal elements which have just been enumerated could, agreeably to the impressed laws of materialism, have been introduced into the universe, and brought into operation *simulta-*

neously, or, if rotation, and consequently centrifugal impetus, had not been inseparable from light, then the recorded fact of the subsequent formation of the higher classes of the animal kingdom would have been unavailing, as concurring testimony in favour of the fundamental assumption of *a protracted period of non-rotation*. But as has already been shown, at great length and with elaborate proof, with respect to TIME, and according to the laws which it pleased the Creator progressively to impress on matter, that *those elements could not have been, with the same results, willed into existence coevally*, a fulcrum is thereby afforded on which to rest the chief lever of the present argument; for there are elements in the constitution of the atmosphere (the atmosphere itself being indispensable to the higher tribes of animals) which indubitably required ages of darkness and of non-rotation to prepare, and render fit to be employed in the formation of the firmament.

The gaseous bases arising from the slow, successive generation of animal and vegetable existences, from their death, decomposition, and the exhalation of their component elements and peculiar secretions, required protracted ages of tranquil submersion and consequent non-rotation, before the primeval waters were in such a condition of saturation with them as, when thrown into sudden and violent agitation, they should produce results commensurate to the object required—before an atmosphere capable of sustaining creatures with powers of locomotion, could have been formed. But the ponderable bases of these gases constitute *part* only of the atmosphere. Of themselves, unassociated with the expansive principle of light, they could not have constituted the atmosphere as it is now beneficially experienced to be. The introduction of light, however, *was*, agreeably to the laws established, *associated* with rotatory motion; and rotatory motion was inseparable from the violent agitation of the waters, and disruption of the strata, which in turn was *inimical* to the generation, extinction, and exhalation of animal and vegetable substances, in the manner and to the extent to which they were required; consequently, although the buoyant principle of light was requisite for the completion of the atmosphere, yet, being as evidently prejudicial to the creation of its two chief elementary materials, free oxygen and azote, it could not, according to divine wisdom, have been introduced into the universe until darkness, tranquillity, and non-rotation had wrought out the designs for which they were, for ages, allowed to predominate over the surface of the shoreless waters.

It is from the fact of the indispensable concurrent and simultaneous presence of those elements for the construction of the atmosphere, contrasted with their no less certain incompatibility of co-existence in time; and shut up, on the other hand, by the evident necessity of the formation of an atmosphere, such as we and the more perfect tribes of animals now enjoy in common—

before they or we could have been willed into existence, together with the announcement of Scripture, at the very juncture when all these elements were at one—that there can be deduced from this source, *the most convincing argument in favour of a non-rotatory period.*

The incompatibility of co-existence as to *time*, and the necessity of being eventually brought into compatible union, so as to produce the end for which several of the elements had been so long preparing, constitute the bases of the argument, and enable me to conclude—*that the period of duration which intervened may be measured, by what was required to be done before the two converging lines could meet and be at one, in the formation of the atmosphere:* a consummation which, by the line of argument now adopted, namely, by proving the necessity of aerated blood for the motions of animals, is shown to be absolutely indispensable before the higher tribes of animals could, according to divine wisdom and goodness, have been willed into existence; and such being the case, it seems evident, that the announcement on the part of the inspired historian, of those races having been willed into existence *at the period* recorded by him, implies that he was fully acquainted with all the previous phases through which the earth, in its creation, had passed; and amongst the rest, the protracted stage of non-rotation so indispensable for the generation of the elements of the ponderable bases of the atmosphere. And this, in turn, leads to the final conclusion—

That before the material light could overcome the inertia of the world, and cause the diurnal rotation of the earth, it was necessary that it should have been girded round, by layer after layer of stratified masses of mineral material, arranged according to a preconcerted order of superposition; and, that although during innumerable ages, the submarine surface of this non-rotating sphere was extensively encrusted by widely-spreading masses of vegetation, and by groups of living beings, diligently and submissively working out the designs of the omnipotent Creator, "God over all blessed for ever;" yet not one of the latter of these was possessed of either perfect gills or perfect lungs—in fine, *that there was not a single material being endowed with the faculty of free and full locomotion within the whole range of the solar economy, until after the spheres had been caused to revolve around their axes, the mundane atmosphere had been formed, and the light concentrated around the sun in the centre of the planetary system. And that these stupendous events all took place ages subsequent to the orbital revolution of the sphere, around the unillumined sun, and the whole around their common centre of gravity.*

CONCLUSION.

The undertaking in which I have been so long and so earnestly engaged is now brought to a close. The cares and anxieties of so many years, experienced under such a variety of circumstances, are henceforward to take another direction, to assume another aspect, to go forth in the earnest desire, *that what has been done may be effectual in directing the mind to the true source and origin of all that exists around.*

With more direct reference to the introductory part of the treatise, and somewhat relieved from the restraint imposed by the close reasoning required in the body of the work, I have now to observe that, like travellers in an alpine country, we have followed a winding, but an ascending path, now in one direction, now in another, but turn whichever way we might, the progress has ever been upwards. And having gained the summit, what do we behold? The whole work of creation—a glorious temple laid out in vast, harmonious proportions, stretching far and wide and all around; with its vanishing points leading up to heaven, and pointing, in every direction, to the great Creator! This is what is now beheld, and a rich reward it is for whatever exertions may have been made to attain it.

As the eye, from the eminence it has reached, scans the intellectual scene, far in the distance may be seen a sphere, surrounded by an atmosphereless sheet of turgid waters, revolving in darkness round an unillumined sun, and without any other motion than that which sweeps it through mirky space; without hill, without dale, without light; an orb of black, dull water, wending its way, in measured circuit, through the obscurity of etherless heaven! What can be its destiny? Scrutinized closer and with more searching view it is soon discovered that, hidden under these dark and tremulous waters, the solid crust teems with peculiar *animal life*, and is covered, in many places, by sub-marine forests of *seedless plants;* the humble, but assiduous instruments whereby the Creator, by the same operation, is purifying the waters, and increasing the thickness and the consistency of the solid shell beneath, to wait his future purpose. The waters, too, when examined from time to time,

are found to have become more limpid, and salter than before. And all the elements of this fair world which are to rise out of these preparations are being created, during a period which it has pleased Omnipotence to make known to us as "the beginning."

But "*the beginning*," and the slow progressive labours of *separation* and *assimilation* are about to close. *Time* and the work of *combination* are to commence. The period seen from all eternity has arrived. And hark! A voice "louder than the pealing of many thunders" proclaims from the midst of the universe "Let there be light" . . . . and "let it be divided from the darkness;" and lo! what a mighty transformation has, on a sudden, and by this act of Omnipotent division, taken place!

The motionless watery-bound sphere, starting into newly-begotten life, rises from its slumber of ages, and, revolving around its axis, casts off its liquid cerements, and, bursting asunder the mineral crust which can no longer engirdle its expanded size, thrusts the rocky layers hastily up into continental ridges, towering mountain chains, and massive channel courses, firm, fixed, endurable, to restrain, for ever afterwards, the waters, which, rushing with impetuous haste towards the equator, would, were it possible, have there regained their former ascendancy. But He who bade the rocky barriers rise from under the ancient ocean, had willed it otherwise, and even that uncontrollable rush of waters is made subservient to his will, becomes the instrument of his pleasure.

While yet these revulsions are taking place, the same Omnipotent voice proclaims, "Let there be a firmament in the midst of the waters, and let it divide the waters from the waters;" and transfixed, by words which *will* materialism into its destined condition, the watery vapour and its gaseous associates, thrown, by the violence of the commotion, into upper space, return not thence, but there remain, ready at his command, to convey the superabundant water from off the land, and carry it whithersoever he pleases.

Again it is audibly decreed, "Let the waters under the heaven be gathered into one place and let the dry land appear," and the firmament hastens to fulfil its Maker's injunctions. The misty vapours rise in quick succession from the earth, "the waters under the heaven are gathered together," and are poured into the midst of the seas, and, thus withdrawn, they display the beauteous transformation which has been wrought beneath! for now the land stands out to view, a glorious earth, fresh from its Maker's hand, sending up the residue of the teeming vapours from the newly-formed soil, into the clear blue vault of heaven, unstained, as yet, by the breath of a living being, or the exhalations of a single plant!

The same resistless voice is again heard, in softer, but more life-giving accents, "Let the earth bring forth grass, the herb yielding seed, and the fruit tree yielding fruit after his kind, whose seed is

in itself upon the earth," and that which, before, was dull uncovered soil, and hitherto unproductive, responsive to the words, shoots forth in softest verdure its variegated and attractive covering of "seeding plants and fruitful trees," in full perfection; seeds ripened for reproduction; fruits replenished with their kindred seeds—the whole a pleasing sight of varied shades and colours, forms and foliage.

But even these increase in growing splendour, when, with a power which nothing can resist, the Omnipotent calls in the scattered rays of pristine light around the central orb, to send it forth with concentrated and augmented impetus to the uttermost bounds of the system. Then the pure, spotless, yet untenanted earth, finished in all its loveliness, and glowing in the brightness of the sun's first radiance, revolves, in silence, before its Maker; displaying, at each turn, traces of such matchless beneficence and wisdom of design, that the attendant angelic host, anticipating mankind's adoration, unite in one melodious burst of praise, and "shout for joy."

Not long without a mundane chorus. For soon the water and the soil are made to render up all that is within them of life-admitting and life-sustaining elements; and earth, and air, and seas teem with their respective denizens; each after his kind, all formed alike for life's enjoyment to the full extent of their restricted faculties.

Yet not a living creature amongst them can comprehend the works, the ways, the word of God, their heavenly Father; not one to render him intellectual praise! until it was resolved, in the immutable council of heaven, to make a creature "in the likeness and after the image of the Triune Jehovah;" and man came forth, made after that form and likeness, and by the inspiring breath of God, capable of holding communion with his Almighty Maker; of understanding the revelation He has been pleased to give of his works; and of rendering up intellectual homage for all these blessings!

This glorious vista, the earth, which I have thus endeavoured to depict, and whose formation I have sought to explain, is the temple which God has constructed, and where he is to be worshipped. The azure canopy overhanging it, like a gorgeous pavilion, was stretched forth by his hand; the sea is his, for he made it; he rides on the circle of the clouds, and flies on the chariot of the wind; and the earth itself is but his footstool. *They* all shall perish, but He shall remain, the same yesterday, to-day, and for ever! Oh, then, let us fall down in joyful lowliness before his throne, and casting all we have at his feet, let us ascribe to HIM all honour, and dominion, and praise, world without end, for ever and ever!

APPENDIX A.

EVIDENCES FROM SCRIPTURE.

"In the beginning God created the heaven and the earth.

"And the earth was without form, and void; and darkness *was* upon the face of the deep: and the Spirit of God moved upon the face of the waters."—Gen. i. 1, 2.

Genesis ii. 4. xxiv. 3. 2 Kings xix. 15. 1 Chron. xvi. 26. xxix. 11. 2 Chron. ii. 12. Ezra v. 11, 12. Nehem. i. 5. ix. 6. Job x. 21, 22. xxvi. 5—7. xxxviii. 4—7. Psalm viii. 3. xxiv. 1, 2. xxxiii. 6. lxxxix. 11, 12. xcv. 3—5. xcvi. 5. cii. 25—27. civ. 5—9. cx. 1, 2. cxi. 2—7. cxv. 15. cxxiv. 8. cxlviii. 1—6. Prov. viii. 22—26. Isaiah xlii. 5. xliii. 10—15. xliv. 6. xlv. 5—7, 12, 18. xlvi. 5—9. xlviii. 1—8, 12, 13. li. 12—16. lxvi. 1, 2. Jer. x. 10—13. xxiii. 24. xxvii. 5. xxxii. 17, 27. xxxiii. 2. li. 15, 16. Lam. v. 19. Ezek. xiv. 12—21. Dan. ii. 22. Zech. xii. 1. Mark xiii. 19. John i. 1—3. Acts iv. 24. xv. 18—21. xvii. 23—26. Rom. i. 20. 1 Cor. ii. 10, 11. Col. i. 12—17. Heb. xi. 3. 2 Pet. iii. 5, 6. Rev. i. 8—11. x. 6. xiv. 7.

"And God said, Let there be light: and there was light.

"And God saw the light, that *it was* good: and God divided the light from the darkness.

"And God called the light Day, and the darkness he called Night. And the evening and the morning were the first day."—Gen. i. 3—5.

Psalm lxxiv. 16. civ. 2. Isaiah xlv. 7. Jer. xxxiii. 20—25. Ezek. xiv. 12—21. Dan. ii. 22. Amos iv. 13. v. 8. 2 Cor. iv. 6. Blair's Chron. Tables, copper plate edition, p. 1, Sabbath, 23rd October, 4004 years B. C.

"And God said, Let there be a firmament in the midst of the waters, and let it divide the waters from the waters.

"And God made the firmament, and divided the waters which *were* under the firmament from the waters which *were* above the firmament: and it was so.

"And God called the firmament Heaven. And the evening and the morning were the second day."—Gen. i. 6—8.

Judges vi. 36—40. 1 Kings viii. 35. xviii. 44, 45. 2 Chron. vii. 13. Job. ix. 8. xxvi. 8, 9. xxviii. 25, 26. xxxvi. 27—29. xxxvii. 10—16. xxxviii. 8—10. Ps. viii. 3. lxxiv. 16. xcvi. 5—10. xcvii. 6. cii. 25—27. civ. 2. cxxxvi. 5, 6. cxlvii. 8. cxlviii. 3—8. Prov. viii. 27, 28. Isaiah xlii. 5. xlv. 12, 18. xlviii. 13. li. 12—16. Jer. x. 11, 12. li. 15, 16. Amos iv. 13. Ezek. xiv. 12—21. Haggai i. 10. Zech. viii. 12. xii. 1. 1 Pet. iii. 5. James v. 18. Rev. x. 6.

"And God said, Let the waters under the heaven be gathered together unto one place, and let the dry *land* appear: and it was so.

"And God called the dry *land* Earth; and the gathering together of the waters called he Seas: and God saw that *it was* good."—Gen. i. 9, 10.

Nehem. ix. 6. Job xxxviii. 8—11. Ps. xxxiii. 7—9. xcv. 3—5. cxxxvi. 6. Prov. viii. 27—29. xxx. 4. Isaiah xlii. 5. xlviii. 13. Jer. v. 22. Ezek. xiv. 12—21. Hosea ii. 21—23. Amos iv. 13. Jonah i. 9. ii. 5, 6. Acts iv. 24. 2 Pet. iii. 5, 6. Rev. x. 6. xiv. 7.

"And God said, Let the earth bring forth grass, the herb yielding seed, *and* the fruit-tree yielding fruit after his kind, whose seed *is* in itself, upon the earth: and it was so.

"And the earth brought forth grass, *and* herb yielding seed after his kind, and the tree yielding fruit, whose seed *was* in itself, after his kind: and God saw that *it was* good.

"And the evening and the morning were the third day."—Gen. i. 11—13.

Gen. ii. 5—9. 1 Kings iv. 33. Ps. lxxiv. 16. cxlvii. 8. cxlviii. 9. Isa. xlii. 5. lv. 10. Zech. viii. 12. Heb. vi. 7. Rev. x. 6.

"And God said, Let there be lights in the firmament of the heaven, to divide the day from the night; and let them be for signs, and for seasons, and for days, and years:

"And let them be for lights in the firmament of the heaven, to give light upon the earth: and it was so.

"And God made two great lights; the greater light to rule the day, and the lesser light to rule the night: *he made* the stars also.

"And God set them in the firmament of the heaven, to give light upon the earth,

"And to rule over the day and over the night, and to divide the light from the darkness: and God saw that *it was* good.

"And the evening and the morning were the fourth day."—Gen. i. 14—19.

Gen. viii. 22. xv. 5. Job ix. 8. xxxviii. 31—33. Ps. viii. 3. xix. 1—6. lxxiv. 16, 17. civ. 19. cxxxvi. 7—9. cxlvii. 4. cxlviii. 3—5. Isa. xxxviii. 7, 8. xlv. 12. Jer. xxxi. 35, 36. Ezek. xxxii. 7, 8. Joel iii. 15. Amos v. 8. Rev. x. 6.

"And God said, Let the waters bring forth abundantly the moving creature that hath life, and fowl *that* may fly above the earth in the open firmament of heaven.

"And God created great whales and every living creature that moveth, which the waters brought forth abundantly, after their kind, and every winged fowl after his kind; and God saw that *it was* good.

"And God blessed them, saying, Be fruitful, and multiply, and fill the waters in the seas; and let fowl multiply in the earth.

"And the evening and the morning were the fifth day."—Gen. i. 20—23.

Gen. viii. 17. ix. 1—17. 1 Kings iv. 33. Job xli. 1—34. Ps. l. 10, 11. lxxiv. 16, 17. civ. 25, 26. cxlvi. 6. cxlviii. 7. Ezek. xiv. 12—21. Rev. x. 6.

"And God said, Let the earth bring forth the living creature after his kind, cattle and creeping thing, and beast of the earth after his kind: and it was so.

"And God made the beast of the earth after his kind, and cattle after their kind, and every thing that creepeth upon the earth after his kind: and God saw that *it was* good."—Gen. i. 24, 25.

Gen. ii. 19. vi. 6, 7. vii. 21. viii. 1—3, 20—24. ix. 1—17. Job xxxix, 1—30. xl. 15—24. Ps. l. 10, 11. cxlviii. 10. Jer. xxvii. 5. xxxii. 27.

"And God said, Let us make man in our image, after our likeness; and let them have dominion over the fish of the sea, and over the fowl of the air, and over the cattle, and over all the earth, and over every creeping thing that creepeth upon the earth.

"So, God created man in his *own* image; in the image of God created he him; male and female created he them.

"And God blessed them; and God said unto them, Be fruitful, and multiply, and replenish the earth, and subdue it; and have dominion over the

fish of the sea, and over the fowl of the air, and over every living thing that moveth upon the earth."—Gen. i. 26—28.

Gen. ii. 7—17. iii. 12, 13, 20. v. 1, 2. vi. 6, 7. ix. 1—17. Deut. xxxvii. 18. Job iv. 17. x. 8, 9. Ps. vii. 6—8. c. 3. cxlviii. 11—13. Prov. xiv. 31. Eccles. xii. 7. Isa. xvii. 7. xliii. 5. xlv. 9—11. liv. 5. Jer. xxvii. 5. xxxii. 7. Dan. v. 21—25. Hosea viii. 14. Zech. xii. 1. Mal. ii. 10. Mark x. 6. Luke iii. 38. Acts iii. 27. iv. 24. vii. 20—50. xiv. 15. xvii. 22—27. 1 Cor. xv. 45—47. Ephes. iv. 3—6. 1 Tim. ii. 13. James iii. 9. 1 Pet. i. 17—20. 2 Pet. i. 17, 18. 1 John iii. 1—4. Rev. x. 6. Blair's Chron. Tables, p. 1, Friday, 28th Oct., 4004 B.C.

"And God said, Behold, I have given you every herb bearing seed, which *is* upon the face of all the earth, and every tree, in the which *is* the fruit of a tree yielding seed; to you it shall be for meat.

"And to every beast of the earth, and to every fowl of the air, and to every thing that creepeth upon the earth, wherein *there is* life, *I have given* every green herb for meat: and it was so.

"And God saw every thing that he had made, and, behold, *it was* very good. And the evening and the morning were the sixth day.

"Thus the heavens and the earth were finished, and all the host of them.

"And on the seventh day God ended his work which he had made; and he rested on the seventh day from all his work which he had made.

"And God blessed the seventh day, and sanctified it; because that in it he had rested from all his work which God had created and made."—Gen. i. 29—31. ii. 1—3.

Gen. ii. 4, 5. ix. 1, 17. xiv. 22. xviii. 25. Exod. xx. 11. Deut. v. 12—14. 2 Kings xix. 15. 1 Chron. xvi. 26. 2 Chron. ii. 12. Ezra v. 11, 12. Job xii. 10. xxxviii. 1—11. Ps. xxiv. 1, 2. xxxiii. 9. xc. 1—4. xcv. 15. xcix. 6. ciii. 7. civ. 13—24. cxv. 15. cxix. 89—91. cxxiv. 8. cxlvi. 5, 6. cxlvii. 1—9. Prov. xvi. 4. xxii. 2. xxvi. 10. xxx. 4, 5. Eccles. iii. 11—15. viii. 17. xi. 5 Isa. vi. 3. xxxvii. 16. xl. 12—14, 28. Ezek. xiv. 12—21. Matt. xii. 8. xvii. 3, 4. Mark ii. 27, 28. ix. 4, 5. Luke ix. 30. xvi. 31. John v. 45—47. Acts iii. 22. vi. 11—14. vii. 20—33. xvii. 22—29. 1 Cor. x. 26. 2 Cor. iii. 7—13. Ephes. iii. 9—11. Colos. i. 12—17. Heb. iii. 1—6. iv. 4. Jude i. 9. Rev. i. 8—11. iv. 11. x. 6. xv. 3. xix. 5—16

THEOREMS.

1. That the EARTH is a spheroid of rotation, whose equatorial exceeds its polar diameter about twenty-six miles, the former being 7,925, the latter 7,899 miles. That the oblateness of this ellipsoid deduced from actual measurement, although somewhat less than mathematicians affirm it should be, from calculations based on its dimensions, time of rotation, component materials, law of gravity, and centrifugal force, nevertheless corresponds as nearly as the data for calculation will admit. And that a sphere contains the greatest volume of all bodies of equal surface.

Astronomy, by Sir John Herschel, new edit. Cab Cyc. pp. 117, 121, 122. System of Astronomy, by Margaret Bryan, 1797, pp. 27, 69. Geology, by H. De la Beche, p. 1. Whitehurst's Theory, pp. 3—15 (difference between diameters 36 miles). Mechanics, Cab. Cyc. pp. 24, 157, 158. Geology, by M'Culloch, vol. i. pp. 16—18. Hutt. Theory, by Playfair, pp. 448—504. Watts on the Ellipticity of the Earth, Edin. Phil. Jour. No. VI., pp. 288—293. Encyclopædia Metropolitana, by Prof. Airey. Mrs. Somerville on the Connexion of the Sciences, pp. 8, 48, 58—63, 410. Edin. Jour. of Nat. Hist. p. 28. Prof. Buckland's Bridg. Treat. vol. i. pp. 39, 40. Phillips's Geology, p. 7. Heat, in Cab. Cyc. pp. 195, 196. Disc. on Nat. Philos. by Sir John Herschel, p. 98. De Luc's Letters, pp. 71, 72. Meteorology, by Dr. Thomson, 1849, Introduction.

2. That the EARTH is a non-luminous body, receiving its external light and heat from the sun. And that the heat received is a fixed quantity, subject to the following invariable law, namely, "that the momentary supply varies in the exact proportion of the angular velocity, i. e., of the momentary increase of longitude;" from which it follows, that equal amounts of heat are received from the sun in passing over equal angles round it, in whatever part of the ellipse these angles may be situated.

Astronomy, Cab. Cyc. by Sir John Herschel, new edit. pp. 10, 194, 198, 211, 212. Heat, Cab. Cyc. pp. 350, 382. Optics, by Sir D. Brewster, Cab. Cyc. p. 2. Mrs. Somerville on the Connexion of the Sciences, pp. 11, 19, 82, 85, 86, 254, 265, 277. Geology, by H. T. de la Beche, p. 5. Prof. Whewell's Bridg. Treat. pp. 76—79, 169—172. Chemistry, in Cab. Cyc. p. 91. Daniel's Philos. of Chemistry, pp. 164—166. Phenomena and Order of the Solar System, Dr. Nichols. System of the World, by M. Lambert. Meteorology, by Dr. Thomson, 1849, p. 36, et seq.

3. That the EARTH has a double movement in space; one by which it revolves around its own axis in 24 hours solar time, or in 23 hours 56′ 4.09″ sidereal time, and another movement whereby it performs its periodical revolution, in an invariable plane, around the sun, in what is termed the tropical year, of 365 days, 5 hours, 48′ 49·7″. That these two motions are entirely independent of each other. And that if the Earth did receive its double movement from a single impulse, it is considered, by computation, that the impulse must have passed through a point about twenty-five miles from its centre.

Astronomy, Cab. Cyc. by Sir John Herschel, new edit. pp. 74, 205, 206. System of Astronomy, by Margaret Bryan, 1797, pp. 191—205. Mrs. Somerville on the Sciences, pp. 9, 10, 71, 75, 81—83, 88, 93, 419, 438. Prof. Whewell's Bridg. Treat. pp. 14, 33, 34, 145.

4. That the orbital revolutions of the EARTH and other planets around the sun, almost in the plane of its equator, and of the satellites around

their primaries, are caused by the combination of the sun and the planets' mutual attraction, and an original projectile impulse; whilst the whole system is connected and regulated by the law, of the squares of their periodical times being proportional to the cubes of their mean distances from the sun. That the same laws maintain the comets in their more elliptical orbits, *their* eccentricity depending wholly on the direction and force of the original impulse which put *them* in motion.

Mechanics, Cab. Cyc. pp. 80, 127. Astronomy, by Sir John Herschel, Cab. Cyc. pp. 232—235, 269. System of Astronomy, by Margaret Bryan, 1797, pp. 191—205. Mrs. Somerville on the Sciences, pp. 6, 9—11, 15, 16, 379, 423. Prof. Whewell's Bridg. Treat. pp. 151, 157. Nat. Philos. Cab. Cyc. by Sir John Herschel, pp. 272, 273. Mechanism of the Heavens, by Dr. Nichols, Edin. 1837. Phen. and Order of the Solar System, by Dr. Nichols, pp. 108—124. System of the World, by M. Lambert.

5. That the Earth and other planets have their axes inclined at various degrees of obliquity to the plane of their respective orbits, and that these latter are at different degrees of obliquity to the ecliptic. That the sun, and such of the planets as afford sufficient data for astronomical calculations, are known to have rotatory motion; *that* of the sun being performed in days 25.01154, whilst it also describes a small irregular orbit about the centre of gravity of the system. And that the mean density of the sun is computed to be to that of the earth as 0.2543 is to 1.0.

Astronomy, by Sir John Herschel, Cab. Cyc. pp. 193—195, 209, 240, 243—287, 416. System of Astronomy, by Margaret Bryan, 1797, p. 252, et seq. Ferguson's Astronomy, vol. v. p. 17. Mrs. Somerville on the Sciences, pp. 12—14, 27—29, 76, 184. Geology, by H. T. de la Beche, p. 6. Prof. Whewell's Bridg. Treat. pp. 14, 165, 166. Architecture of the Heavens, Nichols, pp. 175—177. Phen. and Order of the Solar System, pp. 70, 126, 136, 142, 177, et seq. System of the World, by M. Lambert, p. 37, et seq.

6. That the vicissitude of seasons experienced by the Earth is owing to its globular form, the obliquity of the plane of the equator to that of the ecliptic, the parallelism of the earth's axis, and to the orbital motion of the earth around an illumined sun imparting light and heat.

Astronomy, by Sir John Herschel, Cab. Cyc, pp. 194—266. System of Astronomy, by Margaret Bryan, pp. 252—282. Mrs. Somerville on the Sciences, pp. 27, 28, 85, 100. Prof. Whewell's Bridg. Treat. p. 17. Mechanics, Cab. Cyc. p. 14. Phen. and Order of the Solar System, pp. 31, 32, 42, 63—65. System of the World, by M. Lambert. Meteorology, by Dr. Thomson, 1849, pp. xx.—xxiii.

7. That owing to a secular motion in the position of the major axis of the solar ellipse, arising from a direct motion of the perigee and the retrogradation of the node of the earth's equator on the ecliptic (called the precession of the equinoxes), which conjointly accomplish an entire revolution in 20.984 years, a corresponding, gradual, but entire change is going on in the relative positions of the major axis and the line of the equinoxes; which, about 4,000 years before the Christian era, coincided with each other.

And that this secular change is the necessary consequence of the rotation of the earth and the disturbing action of the sun and moon on the redundant matter accumulated about the earth's equator.

Astronomy, by Sir John Herschel, pp. 170—173, 313—334. Geology, by Dr. John Ure, pp. 13, 14. Prof. Playfair's Works, vol. ii. pp. 411—413, vol. iv. pp. 305—307. System of Astron. by Margaret Bryan, 1797, pp. 96, 256. Mrs. Somerville on the Sciences, pp. 21—25, 32—36, 62—76, 91—94, 99, 161—166, 309, 438, 439. Heat, Cab. Cyc. p. 195. Nat. Philos. by Sir John Herschel, pp. 273, 276, 277.

8. That about three-fourths of the earth's surface is covered by the ocean; and, therefore, the aqueous is to the terrestrial surface as 3 is to 1. That the mean depth of the ocean has been variously estimated, the least

being from three to four miles, the greatest from four to five miles. That the mean specific gravity of the earth's outer crust is to that of the aqueous portion as 5 is to 2, whilst its entire mean density is considered to be five times that of water.

Any Treatise on Geography. Geology, by H. T. de la Beche, pp. 2—5. Dr. Young's Lectures, p. 47. Laplace's System, vol. ii. p. 116. Meteorology, supplement, Enc. Brit. Espy on the Philosophy of Storms, 1841. Astronomy, by Sir John Herschel, pp. 22, 23. Prof. Playfair's Works, vol. iii. pp. 438, 439, iv. p. 302. Dick's Christian Phil. p. 60. Prof. Whewell's Bridg. Treat. p. 52. Mrs. Somerville on the Sciences, pp. 63, 89, 106. Geology, by Dr. M'Culloch, vol. i. pp. 21, 32. Prof. Buckland's Bridg. Treat. vol. i. p. 55. Phillips's Geol. pp. 8, 9, 22, 23, 277—282. Edin. New Philos. Jour. vol. viii. 1827. Mechanics, by Laplace, Toplis, pp. 260—266, et seq. Phen. and Order of Solar System, p. 142, et seq. Meteorology, by Dr. Thomson, 1849, p. xix.

9. That the Moon—a non-luminous satellite 2,160 miles in diameter—receives its heat from the sun, its light from the sun and earth; has a triple revolution in space: one by which it accompanies its primary around the sun, and a binary movement (performed by the same motion in 27 days 7 hours, 43′ 11″), consisting of its sidereal path around the earth and rotation around its axis. That owing to this double revolution by a single movement, together with its libration, and *slight* obliquity of axis, the same hemisphere, increased by a narrow zone occasionally seen on either side, presents itself invariably towards the earth.

And that no indications of either continents or oceans present themselves on its earthward disc, although it affords manifestations of being extremely mountainous, the elevations *appearing* to have originated from volcanoes, now extinct.

Astronomy, by Sir John Herschel, Cab. Cyc. System of Astronomy, by Margaret Bryan, 1797, pp. 272—282, 293—298. Connexion of the Sciences, pp. 69—80. Phen. and Order of the Solar System, pp. 149—173. Meteorology, by Dr. Thomson, 1849, p. 337.

10. That according to investigations made by M. de Laplace, for the purpose of determining the stability of the equilibrium of the sea, it has been discovered,

"That the equilibrium of the sea must be stable, and its oscillations continually tending to diminish if the density of its waters be less than the mean density of the earth; and that its equilibrium would not admit of subversion unless the mean density of the earth was equal to that of water or less."

Prof. Playfair's Review of Laplace, vol. iv. p. 304. Mrs. Somerville on the Sciences, pp. 56, 114. Prof. Whewell's Bridg. Treat. pp. 177—180. Astronomy, by Sir John Herschel, Cab. Cyc, Phillips's Geol. pp. 22, 277, 282. Machanics, by Laplace, Toplis, pp. 244—270.

11. That on taking a general view of the great geographical outlines of the world it is seen to be divided, in directions nearly parallel to its axis of rotation, into three great continental ridges, namely, that of North and South America, with the intervening archiepelago. 2nd, Europe and Africa; and 3rd, Asia and New Holland, with the Polynesia, which intervene.

That there is a remarkable similitude in the general contour of these three great divisions, especially between the first and the last, seeming to indicate that their form is due to a common cause. And that within the equatorial zone are situated the most extensive table lands, and the greatest number of islands.

Any map of the world.

12. That the continents, and even the islands, are found to possess a flora of species peculiarly their own. That whilst a considerable number

of plants are common to the northern regions of Asia, Europe, and America, where these continents almost unite; towards the south, where they widely diverge, the floras of these three great divisions of the globe differ very materially, even in the same parallels of latitude.

And that, upon the principle of distinct floral foci of creation, the whole earth has been divided, by botanists, into a certain number of botanical districts, differing from each other almost entirely in their specific vegetation.

Botany, by Prof. Henslow, Cab. Cyc. pp. 294—309. Lyell's Principles of Geology, vol. ii. pp. 69—75, 131. Mrs. Somerville on the Sciences, pp. 278—285. Lyell's Elements of Geology, vol. ii. p. 68. Old Red Sandstone, by Miller, pp. 196—198.

13. That wherever any considerable portion of the earth's surface has been examined by geologists, it has invariably afforded proofs of having been, at one time, submerged in the waters of the ocean.

Lyell's Principles of Geology, vol. i. pp. 49, 51, 146, 153, 155. vol. ii. pp. 312—318, and map. vol. iii. pp. 9, 23, 126, 130—135, 150, 151, 213, 239, 240, 330, 331. Whitehurst's Theory of the Earth, p. 15, et seq. Playfair's Huttonian Theory, pp. 1, 4—6, 40, 144, 145. Laplace's System, vol. ii. p. 116. Werner on Veins, p. 110. Turner's Sacred History. Manual of Geology, by H. T. de la Beche. Jamieson's Illus. of the Cuvierian Theory, pp. 297, 298. Edin. Phil. Jour. No. XV. pp. 116, 117. Dr. Fleming's Letter, pp. xvii. 226—230. Natural Phil. by Sir J. Herschel, Cab. Cyc. pp. 144, 283, Edin. Jour. Nat. History, pp. 67, 68. Bakewell's Introduction to Geol. and any other similar work. Geol. by Dr. M'Culloch, vol. i. pp. 299—334. vol. ii. p. 360. Ancient World, by D. T. Ansted, pp. 5, 6. Old Red Sandstone, by Miller, Edin. Phillips's Treat. on Geology, pp. 45, 47, 48, 51—56, 166, 190—200, 259, 276—295. Lyell's Elements of Geol. vol. i. pp. 10, 72—77, 147, 181—191. Connexion of the Sciences, p. 87. De Luc's Letters, pp. 9, 20, 29—33, 41, 127, and throughout.

14. That the stratified rocks afford sufficient evidence of having been formed in succession, horizontally and tranquilly, by deposition from water, although, in many instances, bearing marks of the water having been gently undulated.[1] That they differ in many respects from the primary amorphous masses.[2] And that the series of the strata is usually found to be constant, "the order in which they succeed one another, when present altogether, being never reversed.[3]

1. Playfair's Huttonian Theory, pp. 4, 21, 42—46, 144, 145, 231, 235. Whitehurst's Theory of the Earth, pp. 15, et seq. espec. 129. Werner on Veins, pp. 10, 11. Edin. Philos. Jour. No. XVI. p. 227. Bakewell's Intro. to Geology. Hist. of British Animals, p. 16. Lyell's Principles of Geology, vol. i. pp. 82, 99, 159. vol. iii. pp. 2, 6, 8, 35, 213, 255, 365. Geology, by H. T. de la Beche. Jamieson on Cuvier. Theory, p. 297. Cuvier's Eloge. of Werner. Nat. Philos. by Sir J. Herschel, p. 284. Connex. of the Sciences, pp. 62, 63, 89. M'Culloch's Geology, vol. i. pp. 12, 67, 463. Prof. Buckland's Bridg. Treat. vol. i. pp. 17, 36, 44. Lyell's Elements of Geol. vol. i. pp. 10, 22, 32—34, 41, 146, 191. vol. ii. p. 388, et seq. Athenæum, No. 985, p. 935. Vindiciæ Geologici, p. 11, 29. Phillips's Geol. pp. 32, 42, 57, 95, 154, 259, 292. De Luc's Letters, pp. 4, 30, 55—65. New Walks in an Old Field, Miller, Edin. 1841. Ancient World, by Ansted, 1847, p. 122, et seq.
2. Geology, by H. T. de la Beche, pp. 490, 491, 492, 508. Humboldt's Superposition, pp. 13, 14. Cuvierian Theory, p. 298. Lyell's Prin. of Geology, vol. i. p. 201. vol. ii. pp. 9, 14, and Gloss. p. 79. Geol. by M'Culloch, vol. i. p. 463. Ancient World, Ansted, 1847, p. 6, et seq.
3. Phillips's Treat. on Geol. pp. 33—37, 41, 42. Ancient World, by Ansted. Whitehurst's Theory of the Earth, pp. 177—179.

15. That when the stratified masses are examined in their order of superposition, they are frequently found to blend with each other in mineralogical character. And when traced continuously to any distance, in a horizontal direction, are found to "thin out" and run into each other, with an almost imperceptible line of junction.

Baron Humboldt on Superposition, pp. 41, 42, 465, 477. Lyell's Prin. of Geol. vol. iii. pp. 8, 14, 38, 375. Geol. by Sir H. T. de la Beche, pp. 262, 404, et seq. Playfair's Huttonian Theory, pp. 83, 84. Geology, by M'Culloch, vol. i. p. 68. vol. ii. p. 217. Prof. Buckland's Bridg. Treat. vol. i. pp. 38, 39. Ancient World, by Ansted, p. 76, et seq. Lyell's Elem. of Geol. vol. i. pp. 6, 27—39, 198, 208. vol. ii. pp. 74, 108. Phillips's Geology, pp. 40, 59. Old Red Sandstone, by H. Miller, Edin. Russell's Egypt, pp. 423—432.

16. That, with the exception of some of the inferior, the stratified rocks

contain innumerable vestiges of vegetable, zoophytic, and animal existences, some of which are of gigantic dimensions in comparison with recent equivalents.[1]

That there appear to have been successive creations in each of these divisions of animal, vegetable, and zoophytic life.[2]

And that they have by their exuviæ contributed largely to the formation of the carboniferous and calcareous strata.

The calcareous matter, increasing in an ascending series, is yet found to be during every epoch precisely similar in its component elements.[3]

1. Humboldt on Superposition, pp. 50, 211, 265, 307, 387. Jamieson's Cuvierian Theory, pp. 336—355. Geol. by H. T. de la Beche. Consolidated List of Fossil Remains. Playfair's Huttonian Theory, pp. 59, 147. Nat. Phil. by Sir John Herschel, p. 283. Edin. Jour. Nat. Hist. No. II. p. 58. Turner's Sacred Hist. Botany, by Prof. Henslow, p. 311. Whitehurst's Theory of the Earth, 1786, p. 29, et seq. Lyell's Prin. of Geology, vol. i. pp. 2, 105, 115, 168. vol. iii. p. 327. New Walks in an Old Field, Edin. 1841. Ancient World, by Ansted, 1847. Phillips's Intro. to Geol. p. 49, et seq. Lyell's Elem. of Geol. vol. i. pp. 8, 61—67, 199—201, 294. De Luc's Letters. Russel's Egypt, pp. 423—432.
2. Geology, by H. T. de la Beche. Whitehurst's Theory of the Earth, 1786, pp. 44—49. Humboldt on Super. p. 50, et seq. 211, 287, 350, 391, 402. Playfair's Hutt. Theory, pp. 163, 164. Hist. of British Animals, p. xv. Bakewell's Introduction to Geol. Jamieson's Cuvierian Theory, pp. 336—355. Dr. Fleming's Hist. of Zoology, vol. i. p. 26. Edin, Phil. Jour. No. XVI. pp. 226—230. Turner's Sacred Hist. New Walks in an Old Field, Miller, Edin. 1841. Lyell's Prin. of Geol. throughout. Nat. Philos. by Sir John Herschel, p. 283. M'Culloch's Geol. vol. ii. p. 415. Buckland's Bridg. Treat. vol. i. pp. 6, 62, 116, 295, 334, 417. Ancient World, by Ansted, London, 1847. Phillips's Geol. pp. 49, 51, 88. Vindicæ Geol. pp. 8, 30. Lyell's Elements of Geol. vol. i. pp. 45, 181, 391, 408. vol. ii. pp. 46, 153, 243, 435.
3. Lamark on Microscopic Mollusca, vide Miliolites. Playfair's Huttonian Theory, pp. 5, 144. De la Beche's Geology, pp. 205, et seq. Lyell's Prin. of Geol. vol. i. pp. 2, 115. vol. ii. pp. 111. 307, 310. vol. iii. pp. 47, 163, 239. Dr. Fleming's Phil. of Zoology, vol. i. p. 26. M'Culloch's Geol. vol. i. p. 12. vol. ii. pp. 57, 207, 262, 414. Buckland's Bridg. Treat. vol. i. pp. 62, 112. Ancient World, by Ansted, London, 1847, p. 54, et seq. Phillip's Geol. pp. 88, 117. De Luc's Letters throughout, especially pp. 53—56, 127.

17. That from the evidence afforded by the position and dislocation of the stratified masses, it is considered that they have been elevated from where they were originally deposited into the inclined positions they now occupy, and by the agency of a force which acted from below upwards.

And that the time occupied in their elevation was very brief comparatively with that which elapsed during their formation.

Prof. Playfair's Huttonian Theory, p. 40, et seq. 219. Geology of England, by Smith, Edin. Review, No. LVIII. p. 318. Bakewell's Intro. to Geol. Geol. by H. T. de la Beche, pp. 24, et seq. Whitehurst's Theory of the Earth, pp. 115—130. Humboldt on Superposition, p. 69. Connexion of the Sciences, p. 89. Lyell's Prin. of Geol. vol. i. pp. 102, 156, 456. vol. iii. pp. 8, 105, 148, 151, 180, 195, 284—307, et seq. Geol. by Dr. M'Culloch, vol. i. pp. 88, 126. Prof. Buckland's Bridg. Treat. vol. ii. pp. 3, 541. Phillips's Geol, pp. 59—62, 140, 187, 210, 260, 262—276, 280. Lyell's Elem. of Geol. vol. i. pp. 94—96, 101, 146, 296. vol. ii. pp. 14, 20, 22, 356, 362. New Walks in an Old Field, Miller, 1841. Vindicæ Geol. p. 11. Disc. on Nat. Philos. by Sir J. Herschel, p. 284. De Luc's Letters, 1st and 2nd. Ancient World, Ansted, 1847, p. 106, et seq. Russel's Egypt, 423—432.

18. That in contrasting the secondary with the tertiary formations, a marked difference is observable in many respects between them; the former being generally more continuous in their series and more equal in mineralogical character than the latter, and especially than their more recent portions, which are found situated in detached basins surrounded by primary and secondary formations, in very many instances without either being deranged or altered by them.

Geol. of England, by Smith. Edin. Review, No. LVIII. p. 318. Lyell's Prin. of Geol. vol. i. p. 155. vol. ii. p. 313. vol. iii. pp. 15, 23, 229, 289, 296, 303, 309, 320, et seq. Geol. by H. T. de la Beche, pp. 192, 193, 197—199. Geol. by Dr. M'Culloch, vol. i. pp. 313, 324, 478. Prof. Buckland's Bridg. Treat. vol. i. pp. 77, 527. Ancient World, by Ansted, pp. 6—23, 73, 265, 266. Phillips's Geol. pp. 43—62, and diagram, and pp. 161—178. Lyell's Elements of Geol. vol. i. pp. 31, 270, 284, 327—330, 381. vol. ii. pp. 34, 313, 334, 348, 365. Botany, in Cab. Cyc. pp. 311—314.

19. That the state of perfect preservation in which the fossil remains of plants and shells are frequently found affords conclusive evidence that,

in such instances, they grew and lived not far from where they are now found embedded. And that none of the plants belonging to the coal formations have been recognised as being of marine origin.

Botany, by Prof. Henslow, Cab. Cyc. p. 311. Geol. by H. T. de la Beche, p. 439, et seq. Whitehurst's Theory of the Earth, 1786, p. 59, et seq. esp. 121. Lyell's Geol. vol. i. pp. 97, 117, 118. Philos. of Zoology, by Dr. Fleming, vol. ii. p. 88. Turner's Sacred History. Writings of M. Ad. Brongniart, on Fossil Vegetation. New Walks in an Old Field, Miller, 1841. Connexion of the Sciences, p. 85. Geol. by Dr. M'Culloch, vol. i. pp. 437, 438. vol. ii. p. 359. Dr. Buckland's Bridg. Treat. vol. i. pp. 16, 17, 634. Ancient World, by Ansted, London, 1847. Lyell's Elements of Geol. vol. ii. pp. 106—120, 128—130, 133—135. Phillips's Geol. pp. 47, 54, 107, 118. De Luc's Letters, generally, but esp. 2nd Letter, pp. 56—58. Russel's Egypt, pp. 423—432.

20. That considering the granitic, trappean, serpentinous and other rocks of similar origin to have been injected amongst the stratified masses; and that evidence still remains of great heat having been present when and where these protrusions took place—shown as well by the structure of the igneous injections themselves as by the fused, altered, rent condition, and slaty cleavage of the rocks contiguous to them—it is, likewise, considered that the extent of the alteration and the insensible transition of the altered mass, are in direct proportion to the volume of that which has been injected.

Playfair's Huttonian Theory, pp. 21—33, 54, 63, 84, 89, 182—190, 247. Humboldt on Superposition, p. 46. Werner on Veins, pp. 122, 124—126. Whitehurst's Theory of the Earth. Geology, by H. T. de la Beche, pp. 24, 486—489, 491—495, 506, 510, 575, et seq. Edinburgh Review, No. LXXIII. p. 243, Art. Trans. Camd. Soc. Lyell's Prin. of Geol. vol. iii. pp. 12, 79, 108, 367—374. M'Culloch's Geol. vol. i. pp. 126—128. vol. ii. pp. 98, 127, 208. Prof. Buckland's Bridgewater Treat. vol. i. p. 55. vol. ii. p. 9. Ancient World, by Ansted, pp. 6—32, et seq. Lyell's Elem. of Geol. vol. i. pp. 13—18, 191. vol. ii. pp. 214—226, 241, 255—263, 264—292, 300—305, 350, 401—434. Phillips's Geol. pp. 44, 61, 75, 82, 90, 110, 140, 231—239. Old Red Sandstone, by Miller, Edin. Russel's Egypt, pp. 423—432.

21. That all geologists make use of terms indicating that their discourses have reference to an "external crust," "outer coating," or as it is sometimes called, "shell" of the earth, but generally without explaining to what depth these are considered to penetrate into the *viscera terræ:* yet, sufficient has been said to show that these expressions are considered to refer to that which has limits not far from the surface; and, even, in a few instances, an attempt has been made to draw a clear line of separation, at no great depth below the surface, between the solid crust and the supposed internal masses.

MSS. by M. Elie de Beaumont, as given by M. de la Beche, pp. 2, 518. Astron. by Sir John Herschel, pp. 22, 23. Nat. Philos. by the same, Cab. Cyc. p. 288. Geol. by Dr. M'Culloch, vol. i. pp. 94—97. Connexion of the Sciences, pp. 90, 260. Lyell's Prin. of Geol. vol. iii. p. 8, defined at p. 68, Appendix. New Walks in an Old Field, Miller, 1841. Chemistry, by Hugo Reid, p. 140, defined. Brooke's Crystalography, Introd. p. i. Prof. Buckland's Bridg. Treat. vol. i. pp. 37, 38. Ancient World, by Ansted, 1847, p. 15, et seq. Lyell's Elements of Geol. vol. i. pp. 1—3, 191. vol. ii. 141, 192, 349, 354—369. Phillips's Geol. pp. 5, 69—78, 108, 250—258. Vindiciæ Geol. p. 29. De Luc's Letters, pp. 104—108.

22. That thick and extensive beds of breccia and conglomerate, in which the fragments are generally united by calcareous and other mineral substances, are found to intervene amongst the various series of the older and the secondary stratified masses, especially in the vicinity of mountain chains, and above and below the coal formations.

Playfair's Huttonian Theory, pp. 5, 45, 51, 209—211. Lyell's Prin. of Geol. Appendix, vol. iii. p. 64. Geol. by H. T. de la Beche, pp. 214—219, 323, 329, 400—403, 405—408, 491. Jamieson's Illust. of Cuvierian Theory, p. 304. Humboldt on Superposition, pp. 269, 276—278. Geol. by Dr. M'Culloch, vol. i. pp. 89, 226, 459, 464. vol. ii. pp. 222—224. New Walks in an Old Field, Miller, 1841. Lyell's Elements of Geol. vol. i. pp. 7, 76, 101, 365. vol. ii. pp. 148, 298, 356, 370. Vindiciæ Geol. p. 29. De Luc's Letters, pp. 66, 67. Phillips's Geol. pp. 92, 104, 115, 126, 293. Russel's Egypt, pp. 423—432.

23. That although a diversity of opinion prevails among geologists as

to the origin, classification, and the nomenclature by which the greater groups of rocks composing the earth's outer surface are to be designated; nevertheless, an accordance has been come to as regards the unstratified amorphous masses in contradistinction to all the stratified ones of every denomination.[1]

That they also concur in considering the primary rocks, besides being deficient in organic remains, to be more compact and crystaline in texture than the others,[2] and generally more elevated in their positions.[3] That they appear, in very many instances, to have been thrust up from beneath the strata, raising these up also, whether they have perforated or not wholly cut through them; in the former case remaining flanked by stratified masses, which repose upon them in evident unconformity.[4]

1. Comparative Tables in Geol. by De la Beche, pp. 38, 500. Humboldt on Superposition, pp. 30, 41, 114, 130, 133, 357. Lyell's Prin. Geol. vol. iii. pp. 5, 10, 108, 324, 332, 374, 386—393. Jamieson's Cuvierian Theory, pp. 298—300. Sir H. Davy's Agricult. Chemistry. Geol. by Dr. M'Culloch, vol. ii. pp. 68—80. Prof. Buckland's Bridg. Treat. vol. i. p. 39. New Walks in an Old Field, Miller, 1841. Ancient World, by Ansted. Lyell's Elements of Geol. vol. i. pp. 4, 10, 21, 182—187, 191, 209. Phillips's Geol. pp. 42, 45, 68, 69, 95, 259. De Luc's Letters, No. I. pp. 7, 8, 60—65.
2. Manual of Geol. by H. T. de la Beche. Playfair's Huttonian Theory, pp. 84, 85. Jamieson's Cuvierian Theory, pp. 297, 298. Edin. Phil. Jour. No. XV. p. 121. No. XVI. p. 244. Lyell's Prin. of Geol. vol. iii. pp. 10, 108, 117, 334, 353, 364, 377. Geol. by M'Culloch, vol. i. p. 12. Brooke's Crystalography, p. ii. Prof. Buckland's Bridg. Treat. vol. i. pp. 5, 36, 40, 55. Lyell's Elements of Geol. vol. ii. pp. 246, 247. Phillips's Geol. p. 259.
3. Geol. by H. T. de la Beche. Edin. Philos. Trans. No. XV. p. 121. Humboldt on Superposition, pp. 68, 69. Playfair's Huttonian Theory, pp. 52, 83, 209. Cuvier's Eloge. of Werner. Nat. Philos. by Sir John Herschel, pp. 284, 285. Lyell's Prin. of Geol. vol. i. p. 156. vol. iii. pp. 10, 37, 79, 353. Prof. Playfair's Works, vol. iii. pp. 410, 413. Lyell's Elements of Geol. vol. i. p. 21. New Walks in an Old Field, Miller, 1841.
4. Geol. by H. T. de la Beche. Playfair's Hutt. Theory, pp. 47, 50, 83, 209, 230, 247, 311. Lyell's Prin. of Geol. vol. i. pp. 61, 101, 156. vol. iii. pp. 77, 117, 164, 185, 364. Gloss. p. 79. Lithological Survey of Schehallion, Playfair's Works, vol. iii. pp. 403—440. New Walks in an Old Field, Miller, 1841. Capt. Ross's 2nd Voyage, 1829—1833. Capt. Parry's Voyage to Northern Seas. Jamieson's Cuvierian Theory, p. 298. Geology, by Dr. M'Culloch, vol. i. p. 12. Prof. Buckland's Bridg. Treat. p. 36. vol. ii. pp. 3, 4. Phillips's Geol. pp. 42, 55—57. Lyell's Elem. of Geol. vol. ii. p. 264, et seq.

24. That there exists an essential mineralogical difference between the older crystaline rocks, such as granite, trap, porphyry, serpentine, and others of that age and denomination, considered to be of igneous origin, and those which have been ejected from modern volcanoes, distinguished by the name of lavas,[1] a difference attributed to the greater pressure under which the older masses were formed, to the non-action of the atmosphere and consequent retention of their gaseous or volatile parts, and to the more gradual manner in which they have cooled down.[2]

1. Geol. by De la Beche, pp. 493, 501. Nat. Philos. Cab. Cyc. p. 269. Playfair's Hutt. Theory, pp. 67, 80, 260, and his own Works, vol. i. pp. 97—108. Lyell's Prin. of Geol. vol. i. pp. 147, 456. vol. ii. pp. 11, 108, 117, 124, 353, 359, 364. Whitehurst's Theory of the Earth, p. 245, et seq. Lyell's Elements of Geol. vol. i. p. 14. vol. ii. pp. 189—195, 201—254, almost throughout. Phillips's Geol. pp. 187, 238, 240.
2. Geol. by De la Beche, pp. 5, 475, 47. Nat. Philos. Cab. Cyc. pp. 269, 270. Playfair's Hutt. Theory, pp. 21, 68, 135, 181, 184, 260. Lyell's Prin. of Geol. vol. i. p. 148. vol. iii. pp. 108, 124, 353, 360, 363, 370. Whitehurst's Theory of the Earth, p. 245, et seq. Prof. Buckland's Bridg. Treat. vol. i. p. 41. Lyell's Elements of Geol. as above. Phillips's Geol. as above.

25. That Granite is found to be essentially the same wherever it hitherto has been examined. That it is in the deeper regions of the globe, where granite has its origin, that that of trap must also be looked for. That whatever difference may exist between these rocks, whether in their relation to the strata or their mineralogical character, they are remarkably analogous in almost every important general circumstance.

And that there is good reason even for considering that granite, porphyry, and trap have had a common origin.

Geol. by Dr. M'Culloch, vol. i. pp. 145—160, 196. vol. ii. pp. 81—83, 93, 102, 412. Lyell's Prin. of Geol. vol. iii. pp. 361—363. Playfair's Works, vol. i. p. 95, et seq. Prof. Buckland's Bridgewater Treatise, vol. i. pp. 46—48, and map in vol. ii. Phillips's Geol. pp. 32, 33, 42—45. Ancient World, by Ansted, pp. 16, 17. Lyell's Elements of Geol. vol. i. p. 14—20. vol. ii. pp. 186, 191—197, 200, et seq. De Luc's Letters, Intro. pp. 58, 142. Letter 2nd, p. 67. Geol. by H. T. de la Beche, p. 486, et seq. Old Red Sandstone, by Miller. Russel's Egypt, 423—432.

26. That the granitic, trappean, serpentinous, and porphyritic descriptions of amorphous rocks generally constitute the nucleii or centres of mountain ranges, and together with their recumbent strata attain the greatest elevations throughout the world.[1] And that conjointly they occupy a considerable portion of its terrestrial surface.[2]

1. Playfair's Hutt. Theory, pp. 84, 343. Jamieson's Cuvierian Theory, p. 298. Geol. by H. T. de la Beche, pp. 484, 485. Sir H. Davy's Agricult. Chemistry. Lyell's Prin. Geol. vol. i. p. 115. vol. iii. pp. 10, 283, 353. New Walks in an Old Field, Miller, 1841. Capt. Ross's Voyage, 1829, p. 33. Playfair's Works, vol. ii. pp. 403—440. Geol. by Dr. M'Culloch, vol. i. pp. 132, 133. vol. ii. p. 89. Literary Gazette, 5th Nov. 1836, pp. 714, 715. Prof. Buckland's Bridg. Treat. vol. ii. pp. 3—10. Lyell's Elements of Geology, vol. ii. pp. 147, 185, 345—424. Vindiciæ Geol. p. 18. Phillips's Geol. pp. 42, 60, 71—79. De Luc's Letters, No. I. pp. 7—9, 60—63.
2. Playfair's Hutt. Theory, pp. 342, 350. Geol. by H. T. de la Beche, pp. 483—485. Capt. Ross's Voyage during 1829—1833. Lyell's Prin. of Geol. vol. iii. pp. 108, 381. Literary Gazette, 5th Nov. 1836, p. 714. Geol. by Prof. Phillips, pp. 32, 33, 42. De Luc's Letters. Lyell's Elements of Geol. vol. ii. p. 186, et seq. Russel's Egypt, pp. 423—432.

27. That in mountain ranges certain axis of elevation are recognizable; while the outlines of the former frequently assume lengthened, irregular, conical forms, with one or more peaks, whose nucleii and apices usually consist of primary rocks.

And that it may be considered as an established fact, both in geology and geography, that these ranges are, in general, comparatively less elevated in extreme latitudes.

Geol. by H. T. de la Beche, pp. 484—486, 490, 513. Playfair's Hutt. Theory, p. 307. Jamieson's Cuvierian Theory, p. 298, and map. Lyell's Prin. Geol. vol. i. p. 61. vol. iii. p. 353. Playfair's Works, vol. iii. pp. 410—413. New Walks in an Old Field, Miller, 1841. Any geological map of mountain ranges. Any scale of the comparative heights of mountains. Edin. Phil. Jour. No. XVI. pp. 233, 234. Phillips's Geol. pp. 59—62. Captains Ross and Parry's Voyages to the Arctic Regions. The Connexion of the Sciences, pp. 56, 86. Lyell's Elements of Geol. vol. ii. pp. 30, 185, 277—304, 371—373. Phillips's Geol. pp. 8, 60, 71, 93, 266—270. Ancient World, by Ansted, 1847, pp. 106, 107, et seq. De Luc's Letters, No. I. pp. 7, 60. Russel's Egypt, pp. 423—432.

28. That it is not only the greater geographical height of the intertropical mountains which denotes the presence of a comparatively increased force in the regions where they are elevated, but their geological structure corroborates the same assumption. For, "rocks similar to those which constitute the ridge of Jura in the Alps, are found to occupy the plains of England; and basalts which repose on the granites of the Andes are discovered beneath the limestone of Skye."

Geol. by Dr. M'Culloch, vol. i. p. 8. De Luc's Letters throughout, espec. pp. 60—62. Letter 3rd, pp. 106, 107.

29. That when a view is taken of any geological map, it is observed that the formations represented by it are intersected by veins of granite, porphyry, senite, trap, serpentine, greenstone, &c., and by dykes of similar material, especially of trap and basalt. That whatever may be the nature or position of the formations through which they pass, the *general* direction of the main trunks of these veins and dykes is perpendicular to the earth's surface, although their branches frequently diverge and weld the several formations together in a remarkable manner. And that overlying masses of the same materials are frequently found on the surface as if they had overflown from the veins while in a state of fusion.

Playfair's Hutt. Theory, pp. 55, 63, 74, 81, 87, 313. Geol. by H. T. de la Beche, pp. 491—493.

Trans. Camb. Soc. Edin. Review, No. LXXIII. pp. 239—248. Lyell's Prin. Geol. vol. i. pp. 71, 302. vol. iii. pp. 12, 36, 90, 357, 371, 372. Geol. by Dr. M'Culloch, vol. ii. pp. 90, 95, 143. Prof. Buckland's Bridg. Treat. map in vol. ii. pp. 3—5. Phillip's Geol. pp. 42, 62, 111, 112, 186. Lyell's Elements of Geol. vol. i. p. 12. vol. ii. pp. 185—187, 202, 212—219, 262, 357—372.

30. That two distinct classes of mineral veins are found to exist in the earth's outer crust—one of which proceeds from inwards outwards, having their bases in the interior, and their apici nearest to the surface; and the other termed *Faults* and *Fissures*, proceeding from outwards inwards, with their apici in the interior and their bases on or near to the surface. And that displacement of the strata is almost invariably attendant on the faults above referred to.

Werner on Veins, pp. 50—59, 64, 90, 104, 110, et seq. Humboldt on Superposition, pp. 413, 414. Playfair's Hutt. Theory, pp. 61—66, 74, 87, 311. Lyell's Prin. Geol. vol. iii. pp. 36, 353—357, 371. Geol. by Dr. M'Culloch. vol. i. pp. 139—145, 163—165. Geol. by H. T. de la Beche, p. 165, et seq. Prof. Buckland's Bridg. Treat. vol. i. pp. 542—545. Geol. of England and Wales, by Rev. W. Conybear, part i. p. 348. Lyell's Elements of Geol. vol. i. pp. 12, 127—134. vol. ii. pp. 213, 311. New Walks in an Old Field, Miller, 1841, sectional view in frontispiece. Vindiciæ Geol. pp. 18—21. Phillips's Geol. pp. 62—108, 110, 260—265. De Luc's Letters, No. III. pp. 125—128.

31. That in the Coal Measures there is considerable persistency of character; those termed "independent" being usually found in strata conformably to and overlying the mountain limestone and the old red sandstone; the whole three formations appearing to have been moved simultaneously, by the influence of great force, from where they were originally formed. That the magnesian limestone and new red sandstone, which usually overlie the coal measures, are, on the other hand, unconformable to them and more horizontal in their position. That the lower portion of the new red sandstone series is generally formed of conglomerate and strata. And, finally, that there is a decided difference between the coal found in the independent formations, and the lignite or brown coal of the more recent deposits.

Geol. by Dr. M'Culloch, vol. ii. pp. 295—334. Geol. by H. T. de la Beche, pp, 413—448. Art. Coal, Dr. Ure's Chem. Dic. Prof. Buckland's Bridg. Treat. vol. i. pp. 64, 524. Lyell's Elements of Geol. vol. i. pp. 29, 30. vol. ii. pp. 95, 104, 105, 121, 131, 145, 279—297. Ancient World, by Ansted, p. 73, et seq. New Walks in an Old Field, Miller, 1841. Vindiciæ Geol. pp. 18—21. Connexion of the Sciences, p. 86. Botany, by Prof. Henslow, Cab. Cyc. pp. 202, 311. De Luc's Letters, No. IV. pp. 110, 155—157, 162. Ancient World, by Ansted, 1847.

32. That the formation called the New Red Sandstone Group is considered to be of mechanical origin and of heterogeneous composition; containing different kinds of fossil salts associated with gypsum, and much conglomerate and breccia.

That, conjointly with the oolitic group, it frequently contributes to form extended tracts of level land, having aided in filling up immense hollows on the earth's surface at a time when, or immediately after, this latter had undergone a great and widely-extended revolution in its physical form, and in the condition of its vegetable and animal life.

And that although most usually the deposits of rock salt are associated with the strata of the new red sandstone formation, yet they are not unfrequently found in the oolitic, cretaceous, and even in the tertiary formations.

Lyell's Prin. Geol. vol. iii. pp. 228—230, 333, 392. Humboldt on Superposition, pp. 308—324, 345. Dr. Murray's Elements of Chemistry, vol. ii. p. 291. Chemistry, by Hugo Reid, p. 142. Geol. by H. T. de la Beche. Smith's Geol. of England, in No. LVII. Edin. Review, pp. 330. Hist. of British Animals, by Dr. Fleming, p. xvi. Cuvier's Eloge. of Werner. Geol. by Dr. M'Culloch, vol. i. pp. 274, 482. vol. ii. pp. 37, 214, 227, 232, 260, 288—294. New Walks in an Old Field, Miller, Edin. 1841. Prof. Buckland's Bridg. Treat. vol. i. pp. 3, 71, 390. Ansted's Ancient World, pp. 106—118, 130, et seq. Lyell's Elements of Geol. vol. i. pp. 104, 140, 201, 367—370. vol. ii. pp. 90—96, 102, 134, 242, 282, 350, 357. Phillips's Geol. pp. 65, 114, 120—140.

De Luc's Letters, No. III. pp. 131—136. Nineveh and its Remains, by Layard, vol. ii. pp. 254, 314. Russel's Ancient and Modern Egypt, pp. 368—375, 423—432.

33. That whatever may have been the nature and extent of the revolution, alluded to in the preceding theorem as having affected the earth's surface, it and its attendant circumstances seem to have exercised a direct and material influence over the widely extended deposits, the "Oolitic," and the "Cretaceous Groups;" the Chalk formation being considered the most recent of the secondary series; after whose deposition there appears to have taken place a manifest change in the state and condition of our planet, and also in its vegetable and animal existences.

Geol. by H. T. de la Beche, p. 259, et seq. Humboldt on Super. pp. 68, 377. Bakewell's Introd. to Geol. Playfair's Hutt. Theory, pp. 25, 26. Edin. Phil. Jour. No. XVI. p. 228. Lyell's Prin. Geol. vol. i. pp. 154—158, 161, 550. vol. ii. p. 313. vol. iii. pp. 16, 18, 172, 243, 320, 342. Geol. by Dr. M'Culloch, vol. i. pp. 138, 292, 482. vol. ii. pp. 262, 263. Prof. Buckland's Bridg. Treat. vol. i. pp. 71—77, 267, 273, 282, 334—375, 450. Phillips's Geol. pp. 33, 34, 92, 140, 154, 161, 186—194. Ansted's Ancient World, pp. 106—110, 254, 267, 400. Lyell's Elements of Geol. vol. i. pp. 194, 270, 337, 346, 386, 421. vol. ii. pp. 74, 79, 308—313, 349, 401—403. Old Red Sandstone, by Miller, Edin. 1841.

34. That in several parts of Europe and America immense quantities of travelled debris, gravel, and massive boulders, termed by Sir H. de la Beche "the erratic block group," are found either resting on or embedded in the soil. That the boulders and larger debris, when they have been traced to the nearest fixed group of the same mineralogical character, are generally found to have come from a considerable distance. That those boulders in Britain, Germany, Russia, and North America, whose sites and derivations are ascertained, have been identified with mountain chains existing to the *north* of where they now lie; whilst those in South America seem, on the contrary, to have originated from localities *southward* of their present resting-places. Finally, the position of the gravel and smaller ditritus appears to have been materially modified by local formations.

Playfair's Huttonian Theory, pp. 384, 385, 393, 394. Geol. by H. T. de la Beche, p. 169, et seq. Whitehurst's Theory of the Earth, 1786, pp. 63—66, et seq. Jamieson's Cuvierian Theory, pp. 300, 301. Lyell's Prin. Geol. vol. i. p. 202. vol. iii. p. 148. Geol. by Dr. M'Culloch, vol. ii. pp. 364, 365. Literary Gazette, Feb. 3, 1836, p. 104, and Sept. 3, 1836, p. 565, both by Professor Murchison. New Walks in an Old Field, Miller, 1841. Phillips's Treat. on Geology, pp. 201, 205—216. Ansted's Ancient World, pp. 323—326. Lyell's Elements of Geol. vol. i. pp. 142, 164, 222—225, 231—234, et seq. vol. ii. p. 282, et seq. De Luc's Letters, Introd. p. 25. 1st Letter, pp. 17, 27, 38.

35. That a satisfactory explanation of the trade winds has been given upon certain well-known and established principles, amongst which the following are relevant to the present subject:—

1st. That all portions of the earth's surface have a velocity of rotation in direct proportion to the radii of the circle of latitude to which they correspond.

2nd. That the air, when relatively and apparently at rest, is only so because it participates in the motion of rotation proper to that part of the earth.

3rd. That, consequently, when currents of air set towards the equator from the north or south, they must lag, hang back, or drag upon the surface, in a direction *opposite* to that of the earth's rotation, or from east to west. And, lastly,

That the polar currents, from a deficiency of rotatory velocity, tend by their friction near the equator to diminish the velocity of the earth's rotation; while, on the contrary, the equatorial currents carry the excess of rotatory motion north and south.

Astron. by Sir John Herschel, pp. 128—132. Prof. Whewell's Bridg. Treat. p. 99. Whitehurst's Theory of the Earth, 1786, p. 148, et seq. System of Astron. by Margaret Bryan, 1797, p. 309, et seq. Connexion of the Sciences, pp. 8, 87, 115, 137, 433, 441. Capt. Hall's Voyages and Travels, 2nd series, vol. i. p. 162. Lyell's Elements of Geol. vol. i. pp. 34, 140, 224. vol. ii. p. 301. Principles of Meteorology, by Hutchinson. Meteorology, by Dr. Thomson, 1849, pp. 380—382.

36. That the great size of fossil plants, and the magnitude of fossil shells, when compared with their respective recent equivalents, afford reason to suppose that there existed, when and where they grew and lived, as great a *warmth of temperature** as now exists within the tropics, and, perhaps, even greater. That this warmth was general throughout the *northern*, and such parts of the *southern* hemisphere as have yet been examined.

And it is also considered that there existed in the medium wherein they grew and lived a much greater proportion of carbonic acid than is consistent with present animal and vegetable life.

Botany, by Prof. Henslow, Cab. Cyc. pp. 313, 314. Botany, in Lib. of Useful Know. p. 89. Connexion of the Sciences, pp. 85, 256—272. Manual of Geol. by H. T. de la Beche. Lyell's Prin. Geol. vol. i. pp. 105—118, 145. vol. iii. p. 55. Gloss. p. 72. Elem. Philos. Plants, Decandolle and Sprengel, p. 276. Humboldt on Superposition, pp. 46, 52. Edin. Jour. Nat. Hist. p. 63. Prof. Buckland's Bridg. Treat. vol. i. pp. 452, 462, et seq. Capt. Parry's Voyage, Edin. Phil. Jour. No. VII. p. 152. Fossil Flora, by Lindley and Hutton, vol. i. Ancient World, Ansted, p. 80, et seq. Lyell's Elements of Geol. vol. i. pp. 285, 382. vol. ii. p. 125. Phillips's Geol. pp. 96, 118, 289. De Luc's Letters, p. 110, also Letter V. Architec. of the Heavens, Nichol, p. 106. Old Red Sandstone, H. Miller, 1841.

37. That, besides the phenomena alluded to in the foregoing theorems, reference is made, generally, in Geological Treatises:—

1st. To the changes which are taking place, as the effects of causes now in operation, such as the action of the sea, its encroachments and subsidences, tides, currents, lakes, and rivers, volcanoes, earthquakes, deposits from springs, and the formation of coral reefs and islands. And.

2nd. To the fossil osteological remains of extinct animals, found in various formations, which the industry of geologists has brought to light, arranged, described, and designated by names, usually derived from Greek compounds, expressive of their anatomical developments, and which seem to prove, almost invariably, that the former possessors of these fossilized bones, were wholly distinct from, and not varieties of living species.

Prof. Buckland's Bridg. Treat. vol. i. pp. 79, 94, et seq. Ancient World, by Ansted, London, 1847. Old Red Sandstone, Miller, Edin. 1841. Lyell's Prin. and Elements of Geol. Vindiciæ Geol. pp. 6—9, from Cuvier, pp. 30—38. Phillips's Geol. pp. 184, 211—221, 226. De Luc's Letters, and any modern work on Geology.

38. That Light, according to the Newtonian hypothesis, is supposed to consist of inconceivably minute material particles, emitted by luminiferous bodies, and moving through space with the velocity of 192,000 miles in a second of time. That, according to the *Undulatory* Theory, an exceedingly thin and elastic medium called Ether is supposed to fill all space, and to occupy the intervals between the particles of material bodies; and that the vibrations or undulations of this ethereal medium cause the sensation of Light.

But, whatever may be the mode by which it is considered that light becomes perceptible, its universality and the almost immeasurable distance at which it is perceived throughout space, as well as the amazing rapidity of its vibrations requisite to convey sensations of colour are alike remarkable.

* This "warmth of temperature" must be carefully distinguished from the *heat* which is alluded to in the 20th and 29th theorems, and which is considered to have occasioned the fusion observable in the primary and secondary formations.—Author.

Optics, by Sir D. Brewster, Cab. Cyc. pp. 2, 134, 263. Nat. Philos. by Sir John Herschel, pp. 94, 195—217, 248, et seq. Progress of Philos. Science, by J. Thomson, pp. xxxiv. xxxix. System of Astron. by Margaret Bryan, pp. 5—15. Connex. of the Sciences, pp. 38, 186—188, 190—193, 220—224. Prof. Buckland's Bridg. Treat. vol. i. p. 32. Prof. Whewell's idem, pp. 129, 130. Chemistry, Cab. Cyc. pp. 40—42, 373—375. Heat, idem, p. 400. Electricity, idem, pp. 226, 227. Daniel's Philos. of Chemistry, pp. 164—175, 191. De Luc's Letters, pp. 74—80. Architecture of the Heavens, Nichols, 1837. Meteorology, by Dr. Thomson, 1849, p. 80, et seq.

39. That a pencil of Light can be decomposed either by refraction or by absorption into three primary spectra: namely, a red, a yellow, and a blue spectrum; or into seven distinct colours when the secondary ones are included, viz.: red, orange, yellow, green, blue, indigo, and violet. That it likewise can, by the application of certain refracting and absorbing media, be polarized, or separated into two distinct pencils, one having its pole $+45^\circ$, and another whose pole is -45°. And, that the angle at which Light falls on any object, and the intervening media, very materially affect the nature of the result.

Optics, by Sir D. Brewster, Cab. Cyc. pp. 66—72, 144—147. 159—169, et seq. Connexion of the Sciences, pp. 177, 180, 200, 225, 452. Heat, in Cab. Cyc. pp. 295—297, 399. Daniel's Philos. of Chemistry, pp. 179—181, 193—207. Botany, in Cab. Cyc. pp. 195—198. Hunt on Light, pp. 37—39. Meteorology, by Dr. Thomson, 1849, pp. 37, 218, et seq.

40. That there are two hopothesis respecting the constitution of *Solar Light*, by one of which it is considered to be comprised of different physical principles; and by the other it is supposed to consist of a number of distinct rays capable of being diversely deflected, and possessing different qualities according as they vary in refrangibility. Yet, by the adherents of both hypothesis it is admitted, *that the solar rays do possess chemical properties.*

Heat, in Cab. Cyc. pp. 298—303, 399. Optics, idem, by Sir D. Brewster, pp. 90—93. Art. Light, in Dr. Ure's Chem. Dict. pp. 578—580. Connexion of the Sciences, pp. 225—227. Daniel's Philos. of Chem. p. 456. Hunt on Light. Taylor's Scient. Mem. vol. iii. p. xi. Feb. 1843. De Luc's Letters, p. 78. Meteorology, by Dr. Thomson, 1849, p. 37, et seq. (founded on numerous concurring authorities.)

41. That the surface, lengthways, of the solar spectrum is crossed by dark lines of different breadths, and amounting in number to nearly six hundred. That when sun or moonlight is employed in the experiment, their number, order, and intensity are found to be invariable. And that similar bands are perceived in light from the fixed stars, and from that afforded by electricity; but in the light given by a lamp or candle none of these fixed lines are perceptible.

Optics, by Sir D. Brewster, Cab. Cyc. pp. 85—88, 142. Connexion of the Sciences, pp. 180—182. Astron. by Sir John Herschel, pp. 202, 203. Daniel's Philos. of Chem. pp. 183, 457. Hunt on Light, pp. 40, 41. Meteorology, by Dr. Thomson, 1849, p. 80.

42. That some late and delicate experiments in optics having proved that rays from the sun, even when transmitted obliquely, are *not* polarized, whereas those whieh emanate from incandescent bodies possess this remarkable property, it follows as a consequence, that solar light does not issue from an incandescent solid or fluid, but rather—as Herschel previously supposed—from an exterior film which is the source of its light; and that the intensity of the sun's light diminishes from the centre to the circumference of the solar disc.

Astron. by Sir John Herschel, Cab. Cyc. p. 212. Connexion of the Sciences, pp. 254, 255, 310. Geol. by Dr. Ure, Intro. p. xxxvi. Prof. Whewell's Bridg. Treat. p. 171. Heat, in Cab. Cyc. p. 314. Architec. of the Heavens, Nichol, 1837. Phen. and Order of the Solar System, idem, pp. 170—199. Meteorology, by Dr. Thomson, 1849, p. 83, et seq.

43. That common light moves in straight lines. That when it falls

upon any surface, whether plane or curved, the angle of its reflection is equal to the angle of its incidence. That the intensity of radiant heat and light decreases in direct proportion to the square of the distance. And that one non-luminous body may receive light from another non-luminous body and discharge it upon a third; but in every case *the light must come from a self-luminous body.*

Optics, by Sir D. Brewster, Cab. Cyc. pp. 1, 6, 23—25. Connexion of the Sciences, pp. 170—176, 189. Chemistry, in Cab. Cyc. p. 91. Astron. by Sir John Herschel, p. 212. Daniel's Philos. of Chemistry, p. 166.

44. That the following are some of the best ascertained effects of sunlight upon the vegetable kingdom, namely:—

1st. The quantity of water lost to a plant by evaporation, and its power of absorption from the soil are in proportion to the quantity of light.

2nd. Light causes the decomposition of the carbonic acid of vegetation; and, by solidifying the tissue, renders the parts most exposed to it the hardest. And

3rd. The green parts of plants, when exposed to the direct light of the sun, absorb from the atmosphere carbonic acid, which they decompose, and give back the oxygen.

Botany, by Prof. Henslow, Cab. Cyc. pp. 92, 175, 186. Botany, in Lib. Useful Know. pp. 84—88. Hunt on Light, pp. 200—202. Meteorology, by Dr. Thomson, p. 15 (founded on numerous concurring evidences).

45. That two distinct hypotheses have been proposed respecting the nature of Radiant Heat.

By one it is considered to be a material substance, *sui generis*, capable of combining with other bodies, and by such combination producing the various effects attributed to heat. By the other it is regarded, not as a material substance, but as a *quality* of matter; bodies when heated being supposed to be in a certain state in which their constituent molecules, or the molecules of some subtle fluid which pervades them, are put into a state of vibration; and this vibration is considered the cause of heat.

Heat, in Cab. Cyc. pp. 26, 379, 392—403. Chemistry, by Donovan, Cab Cyc. pp. 40—42, 375—378. Daniel's Philos. of Chem. pp. 164, 208, 228, 685. Connexion of the Sciences, p. 411. Disc. on Natural Philosophy, by Herschel, pp. 195, 310—323. Pollock's Attempt to Explain the Nature of Heat.

46. That the results of careful and repeated experiments prove, "that light and heat either do not possess the property of gravitation, or possess it in so small a degree as to be wholly inappreciable by any known means of measuring it."

Heat, in Cab. Cyc. pp. 394—396. Connexion of the Sciences, pp. 239, 240. Chemistry, by Hugo Reid, p. 102. Chemistry, in Cab. Cyc. pp. 373—375. Electricity, in idem, pp. 1, 227. Daniel's Philos. of Chem. p. 102. Nat. Philos. by Sir John Herschel, p. 300. Hydrostatics, in Cab. Cyc. p. 142.

47. That a comparison of the natural phenomena, in which the effects of Light and Heat are manifested, affords reason to infer the existence of a connection so intimate between them as to warrant the belief of their identity. Nevertheless, although the instances are rare in which light does not emanate from incandescent bodies; yet, on the other hand, intense heat may be excited and communicated without being accompanied by visible light.

Heat, in Cab. Cyc. pp. 22—25, 294, 339—353, 379—381, 398. A Paper read before the Royal Society, by Herschel, May 15, 1800, p. 295. Dr. Faraday's Exper. Researches, vol. ii. System of Astronomy, by Margaret Bryan, 1797, pp. 5—15. Connex. of the Sciences, preface, also pp. 226—233, 237—249, 251, 355. Disc. on Nat. Philos. by Herschel, Cab. Cyc. p. 314. Prof. Whewell's

Bridg. Treat. p. 136. Lectures at the Lond. Instit. by Prof. Grove, 1843 and 1844. Chemistry, in Cab. Cyc. pp. 40-42, 91. Hydrostatics, in idem. Electr. in idem, pp. 162, 163. Daniel's Philos. of Chem. pp. 164--166, 208, 217. De Luc's Letters, pp. 76—80.

48. That by a concurring chain of deductive reasoning, drawn from the effects of the different heating powers of the component colours of the solar spectrum, when applied to substances reflecting various colours and degrees of heat; together with the corroborating testimony of the augmented heat of concentrated light, it is considered to be established, beyond the possibility of doubt, that, in these cases, sunlight is the direct cause of heat.

Heat, in Cab. Cyc. pp. 345—350, 382. Connex. of the Sciences, p. 229. Optics, by Sir D. Brewster, Cab. Cyc. pp. 89, 317, 321. Chemistry, in Cab. Cyc. p. 91. Daniel's Philosophy of Chemistry, pp. 99, 209.

49. That the *attraction of affinity*—distinct from that of cohesion, and the highest degree of heterogeneous attraction, its ratios being determinate quantities—is supposed to be co-existent with matter.

That it is one of the few forces known to act by election, and is productive of the most important results in nature.

And, that during chemical action, heat is either developed or absorbed; whilst caloric and water are the agents most usually employed to facilitate and conduct chemical operations.

Heat, in Cab. Cyc. pp. 3, 21, 25, 191—193, 294—296, 310, 354, 387. Disc. on Nat. Philos. in Cab. Cyc. pp. 310—313. Caloric and Combustion, Ure's Chem. Dict. pp. 353, 368. Chemistry, by Hugo Reid, p. 22, et seq. Connex. of the Sciences, p. 225. Chemistry, in Cab. Cyc. pp. 23—27 384—386, et seq. Electricity, in idem, p. 162. Daniel's Philos. of Chemistry, pp. 101, 219, 306, 325, 338, 397, 444, 523, 685. Physiology and Anatomy of Man, by Todd and Bowman, London, 1845, vol. i. pp. 2, 3, et seq. Dr. Faraday's Chem. Manipulations.

50. That the first and most usual effect of heat is to increase the size of the bodies to which it is imparted, by causing them to dilate or expand.

That, although these effects are produced in different degrees and by different methods, according as the body to which heat is applied be solid, liquid, or aeriform, yet it may be considered as a physical law to which there is no *real* exception, that an increase in the temperature will be accompanied by an increase of volume, and a diminution of temperature by a diminution of volume. And that the force with which solids and liquids expand or contract by heat or cold is prodigious.

Heat, in Cab. Cyc. pp. 8—10, 28—83, 162, 173—175, 187—189, 393. Connexion of the Sciences, pp. 117—120, 243. Chemistry, by Hugo Reid, pp. 22, 23. Mechanics, in Cab. Cyc. pp. 19, 20. Heat, in Chem. Dict. pp. 253—255, 278. Disc. on Nat. Philos. in Cab. Cyc. pp. 319—322, 343. Chemistry, in Cab. Cyc. pp. 10, 42—48, 54—58. Daniel's Chem. Philos. pp. 685—687. Meteorology, by Dr. Thomson, 1849, p. 98, et seq.

51. That the phenomena arising from *attraction* and those from *repulsion* indicate the presence of two antagonistic forces acting at the same time on the particles of all bodies, and maintaining them in a state of equilibrium; which becomes more or less disturbed according as either of these forces preponderates.

Heat, in Cab. Cyc. pp. 2, 8, 11, 17, 185—199, 343. Chemistry, by Hugo Reid, pp. 20, 23. Disc. on Nat. Philos. by Sir J. Herschel, Cab. Cyc. pp. 89, 321. Connex. of the Sciences, pp. 117, 241—243. Chemistry, in Cab. Cyc. pp. 37—44, 49, 58. Hydrostatics, in idem, p. 2. Electricity, in idem, pp. 225, 226. Daniel's Philos. of Chemistry, pp. 13, 17, 99, 450. Mechanics, in Cab. Cyc. pp. 8, 67. Meteorology, by Dr. Thomson, 1849, p. 370.

52. That an irresistible body of analogies leads to the conviction, that the same physical properties, which observation and experience disclose in the smaller masses immediately surrounding us, are possessed by the infinite systems of bodies which fill the immensity of space. That the distri-

bution of heat is regulated by the same laws amongst the bodies of the universe as among those which exist on our globe. That the earth absorbs and radiates heat in the same manner as every body on its surface, and therefore, if there were no external source of heat, the earth would be gradually cooled down and the temperature of all bodies would fall indefinitely.

Heat, in Cab. Cyc. pp. 186, 379—382. Prof. Whewell's Bridg. Treat. p. 76. Dr. Faraday's Researches, vol. ii. pp. 284—293. Daniel's Philos. of Chem. p. 215. Constitut. Sidereal System, Lond. Edin. and Dub. Mag. Feb. 1843. Connexion of the Sciences, pp. 29, 363, 381—389, 401—411. Mechanics, in Cab. Cyc. p. 80. Architecture of the Heavens, Nichol, 1837. Phen. and Order of the Solar System, pp. 218—234.

53. That when a liquid passes into a solid state a sudden and considerable change of dimension is frequently observed; and that it may be considered as a general truth, to which, however, there are exceptions, that bodies which crystalize when they freeze expand in doing so; while bodies which do not crystalize in solidifying, for the most part suffer contraction.

Heat, in Cab. Cyc. pp. 128—131. Chemistry, iu idem, pp. 52—58.

54. That water in vacuo boils at 88° of Fahrenheit; but under the usual pressure of the atmosphere it requires 212°. While, in order to maintain water in a state of vapour, the sum of its latent and sensible heats cannot be less than from 1,130° to 1,212°.

That different bodies undergo the process of liquefaction at different temperatures, called their point of fusion. In like manner, different liquids undergo the process of ebullition, under equal pressure, at different temperatures.

And, lastly, that the states of solidity, liquidity, or of vapour, are not essentially connected with the nature of bodies, but are wholly incidental on their temperature.

Heat, in Cab. Cyc. pp. 15, 118, 127, 143, 151, 166, 183, 194. Dr. Ure's Chem Dict. p. 283. Chemistry, by H. Reid, pp. 36, 37, 101. Connexion of the Sciences, pp. 243—250. Chem. in Cab. Cyc. pp. 52—67, 73—75. Daniel's Philos. of Chem. p. 191. Espy on the Philos. of Storms, 1841. Meteorology, by Dr. Thomson, 1849, pp. 17—19.

55. That oxygen, nitrogen, and hydrogen gases have been severally submitted, by the first chemists of the age, to the enormous pressure of eight hundred atmospheres, without their having succeeded in reducing either of them to the liquid state; although many other gases have been liquidized by their vigorous and well-directed exertions; and that hitherto no satisfactory explanation has been given of the condition in which the atmospheric elements exist in union.

Heat, in Cab. Cyc. pp. 167, 177—179, 192, 344. Connexion of the Sciences, p. 119. Phillips's Geol. p. 26. Chemistry, in Cab. Cyc. pp. 52, 97, 133, 138, et seq. Daniel's Philos. of Chemistry, pp. 57, 100, 310, 322. Meteorology, by Dr. Thomson, 1849, p. 7, et seq.

56. That the atomic theory is understood, by some, to imply that all substances are composed of atoms, on whose magnitude, density, and form, their nature and qualities depend. Others, however, assume these atoms to be—not particles of matter—but *centres of force*, highly elastic, varying in the disposition and relative intensity of the forces around their respective centres; and to be in contact with each other. But all alike concur in the belief that, as these atoms are unchangeable, they must be incapable of wear, remaining the same now as when created.

Dr. Dalton's Chemical Philos. vol. i. Nat. Philos. in Cab. Cyc. by Herschel, pp. 37—42, 323. Heat, in Cab. Cyc. pp. 185, 291—293. Connexion of the Sciences, pp. 117—128. Dr. Faraday's Experimental Researches, vol. ii. pp. 284—293. Chemistry, in Cab. Cyc. pp. 13—40, 361, 384—391.

Daniel's Philos. of Chemistry, pp. 7, 313, 325, 678—695. Mechanics, in Cab. Cyc. pp. 6—16, 67. Phillips's Geology, p. 257. Physiol. and Anatomy of Man, by Todd and Bowman, London, 1845, vol. i. pp. 2, 3, et seq.

57. That when any physical effect is transmitted in straight lines, especially if these lines proceed in various directions round the point whence the effect originates, the phenomena is called *radiation*. The effect is said to be radiated, and the lines along which it is transmitted are called rays.

That radiation, in this sense of the term, is a property of heat, and is independent of any power of transmission which may reside in the air; while it is proved, that the particles forming the surface of a body are not the only ones which radiate, but that this effect also proceeds from particles at a certain small depth within the surface.

Connexion of the Sciences, p. 226. Heat, in Cab. Cyc. pp. 21, 294, 314. Chemistry, in Cab. Cyc. pp. 84—86. Daniel's Philosophy of Chemistry, pp. 209, 214, et seq.

58. That if heat be applied to a solution of salt and water, the repulsive force will cause the atoms of water to separate from the atoms of salt, and carry the former away in pure vapour, while the salt will remain in the form of crystals; the same degree of repulsive force not being capable of overcoming the natural cohesion between *its* particles.

That precisely similar results will ensue if a solution of the same material be exposed to vaporization; which, if continued for a sufficient length of time, will cause the water to disappear altogether, and leave a crystaline mass of salt behind.

Heat, in Cab. Cyc. pp. 192, 207, 244. Dr. Ure's Chem. Dict. Chemistry, by Hugo Reid, pp. 115, 116. Chemistry, in Cab. Cyc. p. 19. Electricity, in idem, vol. ii. p. 81. Daniel's Philos. of Chemistry, pp. 77, 222—225. Mechanics, in Cab. Cyc. p. 14.

59. That Electricity is a physical agent, possessing the properties of a self-expansive fluid.

That all bodies, when in a state of solution, are conductors of electricity. That the mutual attraction or repulsion of two electrified bodies is directly proportional to the quantity of the fluid in the one multiplied by that which is on the other, and inversely proportional to the square of the distance between the two. And that, although several varieties of electricity are known to exist, dependent on the manner in which the electric force is excited, yet they are sufficiently related to one another to justify the conclusion that they all originate from a common principle, and are the effects of one individual power.

Electricity, in Cab. Cyc. vol. ii. pp. 355, 479—482. Connexion of the Sciences, pp. 121, 123, 288, 307, 335. Mechanics, in Cab. Cyc. p. 75. Discourse on Nat. Philos. by Sir John Herschel, pp. 327, 330—333. Lectures in London Instit. by Prof. Grove, 1843, 1844. Harris on Thunder-storms, 1843. New Treat. on Mechanics, London, 1841, pp. 8—10. Meteorology, by Dr. Thomson, 1849, pp. 270—281, et seq.

60. That Electricity is confined, almost exclusively, to the surface of bodies, penetrating only to a depth scarcely appreciable. That the quantity which bodies are capable of receiving is neither proportional to their mass, nor is it affected by their component materials, but depends chiefly on the extent of their surface and their form. That the electric fluid is most easily retained by a sphere; next by a spheroid; while it readily escapes from a point; and a pointed object receives it with the greatest facility.

Electricity, Cab. Cyc. Nat. Philos. by Sir John Herschel, pp. 331, 332. Connexion of the Sciences, pp. 289—294. Harris on Thunder-storms, 1843. Exper. Researches, by Dr. Faraday, vol. ii.

61. That Light, Heat, and Motion, are intimately connected with electrical phenomena. That the most splendid artificial light known is produced by attaching pencils of charcoal, diamond, &c., to the extremities of the wires of a voltaic current, and bringing the points thus prepared into contact. That the most intense heat is generated by electrical action, especially by voltaic electricity. And that some eminent philosophers are inclined to attribute the light and heat of the sun to electrical agency.

Electricity, in Cab. Cyc. Harris on Thunder-storms, 1843. Disc. on Nat. Philos. by Herschel, p. 331. Connexion of the Sciences, pp. 294—313, 353—355. Stait's Electrical Light, Mining Jour. Jan. 1849. Meteorology, by Thomson, 1849, pp. 271, 368, et seq.

62. That there is a strong analogy between MAGNETISM and ELECTRICITY. The agency of attraction and repulsion is common to both, and subject in them to the same laws; their intensities varying inversely, as the square of the distance between the bodies affected by them. That a like analogy extends to magnetic and electrical induction.

And that there is such a perfect correspondence between the theories of magnetic attraction and repulsion, and electro-dynamic forces in conducting bodies, that they not only are the same in principle, but are determined by the same formulæ. While experiment concurs with theory in proving that, with the exception of electrical transference, the identity of these two unseen influences is complete.

Electricity, in Cab. Cyc. Disc. on Nat. Philos. by Herschel, pp. 324, 339. Connexion of the Sciences, pp. 324—327, 331, 338, 341. Prof. Whewell's Bridg. Treat. pp. 110—115.

63. That ELECTRO-MAGNETISM (electricity modified by the physical influences peculiar to certain substances), by overcoming retardation arising from friction, and the obstacle of a resisting medium, maintains perpetual motion. That the force emanating thus mutually from the electric current and the magnetic needle, acts at right angles to the electric current.

"Such circumferential action, arising from the tangential direction of two opposite forces," being unlike any other power hitherto discovered; for, all other known forces emanating from a point and acting upon any other, act in the direction of a line joining these two points; and that in all experiments, undertaken with the design of eliciting the phenomena of electro-magnetism and of magneto-electricity (the converse of each other), rotation round an axis is generally found to accompany them.

Electricity, in Cab. Cyc. Disc. on Nat. Philos. by Herschel, pp. 93, 339. Connexion of the Sciences, pp. 305—309, 328, 338, 456. Edin. Philos. Jour. No. XI. p. 179. No. XV. p. 282. No. XVI. pp. 368—372.

64. That the magnetic action has a circular motion round the connecting wire of a voltaic current, whose course, always constant with respect to each of the poles of a magnet, is similar to the direction of the earth and other planets around the SUN, and about their respective axis; that currents of electricity, analogous to these, are constantly flowing round the earth, at right angles to the magnetic meridian.

And by some it is considered, that the arrangement of the materials composing the outer crust of the globe may be such as to constitute a voltaic girdle, sufficient, though of feeble electric powers, to produce terrestrial magnetism.

Daniel's Philos. of Chemistry, p. 573. Electricity, in Cab. Cyc. Disc. on Nat. Philos. by Herschel, p. 328. Electro-Magnetism, by Dr. Roget, in Lib. Useful Know. Magnetism, in Popular Encyclopædia, pp. 833—837. Connexion of the Sciences, pp. 305, 324, 328, 348. Prof. Whewell's Bridg. Treat. p. 114. Electricity, in Cab. Cyc. p. 208. Edin. Philos. Jour. No. VII. p. 174.

65. That ELECTRICAL INDUCTION is that remarkable influence which is exerted by electrified bodies on other bodies at such distances as to prevent the transfer of any part of the charge, but by which a polar state is communicated to the body under induction, so as to confer upon it equal but opposite powers by a common condition.

That the *magnetic* force of a conducting wire is capable of acting by *induction* on soft iron, and of communicating permanent polarity to steel; this latter induction taking place indifferently through all kinds of matter.

And that the laws of TERRESTRIAL MAGNETISM, although inconsistent with those which belong to a permanent magnet, are perfectly accordant with the conditions peculiar to a body in a state of transient magnetic induction.

Electricity, in Cab. Cyc. Connexion of the Sciences, pp. 291, 347—353.

66. That in light, heat, electricity, and magnetism, principles are exhibited which, although they do not occasion any appreciable change in the weight of bodies, manifest their presence by the most remarkable mechanical and chemical effects.

And that these agencies are so connected as to afford every reason to believe they will ultimately be referred to some one power of higher order, in conformity with the general economy of the system of the world; in which the most varied and complicated effects are produced by a small number of comprehensive laws.

Experimental Researches in Electricity, by Dr. Faraday, vol. ii. p. 15. Connexion of the Sciences, pp. 309, 352—355, 412, 413. Prof. Whewell's Bridg. Treat. p. 138. Harris on Thunder-storms, 1843. Meteorology, by Dr. Thomson, 1849, pp. 271, 278, et seq.

67. That one of the most important qualities of matter in mechanical investigation is INERTIA, or that property which results from its inability to produce in itself spontaneous change or action, either from a state of rest to that of motion, or vice versâ, to diminish any motion which it may have received from an external cause, or to change its direction.

That, since by this quality of *inertia*, a body can neither generate nor destroy motion, it follows: that when two bodies act on each other, in any way whatever, the total quantity of motion in any given direction after the action takes place, must be the same as before. And that any two bodies are considered to have equal quantities or masses of matter when they possess equal inertia.

Mechanics, in Cab. Cyc. pp. 27—33, 37, 38, 44, 63—74. Chemistry, in idem, p. 2. Electricity, in idem, p. 225. Daniel's Philos. of Chem. pp. 9, 10. Disc. on Nat. Philos. by Sir John Herschel, pp. 223, 297. Mechanics, by Laplace, Toplis, 1814, pp. 23—30. New Treatise on Mechanics, London, 1841, pp. 2, 83.

68. That the molecules of bodies are not placed together merely in unrelated juxtaposition, but either cohere and resist separation, or mutually repel each other; while the mutual approach, by attraction of particles placed at a distance from each other, or their further separation by repulsion, are effects of the same class, both of which are termed FORCE. That, therefore, "whatever produces or opposes the production of motion or pressure in matter is *force;*" in which sense it is the name or symbol for the unknown *cause* of a known *effect*. That FORCE, when manifested by the mutual approach or cohesion of bodies, is called ATTRACTION; separable into as many branches as it has distinct modes of displaying itself. But when FORCE is indicated by the re-motion of bodies from each other, it is called *repulsion* or *expansion*.

Mechanics, in Cab. Cyc. pp. 6—8, 49, 63. Discoveries by an Italian Philos, Lit. Gazette. Lectures by Prof. Grove, London Inst. 1843-4. Chemical Dict. Dr. Ure's, pp. 253, 278. Chemistry, in Cab. Cyc. pp. 27—30. Daniel's Philos. of Chemistry, pp. 11, 13—18. Disc. on Nat. Philos. Herschel, pp. 225—228. Mechanics, by Laplace, Toplis, 1814, pp. 1, 30. New Treatise on Mechanics, London, 1841.

69. That the tendency to assume and maintain a state of equilibrium—the effect of counteracting forces—is a prevailing condition of the material universe; that it is exemplified alike by the invariable plane passing through the centre of gravity of the solar system, around which, as a fixed centre, the great secular changes of the system oscillate; by the static forms assumed by fluid bodies, under rotation; by the normal condition of the ocean and of the atmosphere; and by the combinations produced by the satisfaction of chemical affinities; that the stability of the equilibrium or difficulty of subverting it, is in proportion to the magnitude and importance of the constituted body; and that it cannot be disturbed, in any of its states, without the operation of a sufficient and corresponding cause.

Mechanics, in Cab. Cyc. pp. 65, 74, 116. Connexion of the Sciences, pp. 306, 307. Disc. on Nat. Philos. by Sir John Herschel, Cab. Cyc. pp. 90, 222, 275, 281. Architecture of the Heavens, Nichol, pp. 185—187. Phen. and Order of the Solar System, idem, pp. 231, 232. Harris on Thunder-storms, pp. 4, 10. Ancient World, by Ansted, 1841, p. 384, et seq. Meteorology, by Dr. Thomson, 1849, p. 370. Baron Humboldt's Cosmos.

70. That the law of Gravitation is, "That the mutual attraction of two bodies increases as their masses are increased, and as the square of the distance between them is diminished; and it decreases in proportion as their masses are decreased, and as the square of their distance is increased." That this law—which is irrespective of the quality of matter—extends not only over the planetary system, where its effects have been submitted to rigorous calculation, but is supposed to pervade the whole material universe; and that, as the motions of celestial bodies are independent of their absolute magnitudes and distances, if all the bodies of the solar system, their mutual distances, and their velocities, were to diminish proportionally, they would describe curves in all respects similar to those in which they now move.

Mechanics, in Cab. Cyc. pp. 75—79, 81—102. Astronomy, by Sir John Herschel, ditto, pp. 237, 389—394. System of Astron. by Margaret Bryan, pp. 22, 186—205. Connexion of the Sciences, pp. 1—7, 381, 407—409, 412. Whitehurst's Theory of the Earth, pp. 6—9. Treatise on Double Stars, by M. Arago, Edin. Jour. Science. Prof. Whewell's Bridg. Treat. pp. 214—239. Dr. Faraday's Experimental Researches, vol. ii. pp. 284—293. Chemistry, in Cab. Cyc. pp. 3, 4, 27—29. Disc. on Nat. Philos. by Sir John Herschel, in Cab. Cyc. pp. 56, 72, 255, 280. Philos. of Chemistry, by Daniel, pp. 20, 21. Architecture of the Heavens, Nichol, 1837, pp. 152, 153, 211, et seq. Mechanics, by Laplace, Toplis, pp. 52, 285, 286. New Treatise on Mechanics, London, 1841, pp. 7, 31. Phen. and Order of the Solar System, Nichol, pp. 208—281.

71. That as results of the principles mentioned in the preceding theorems, there have been adduced by Sir Isaac Newton, the following three comprehensive rules, called the *laws of motion*, namely:—

1st. Every body must persevere in its state of rest, or of uniform motion in a straight line, unless it be compelled to change that state by forces impressed upon it.

2nd. Every change of motion must be proportional to the impressed force, and must be in the direction of that straight line in which the force is impressed.

3rd. Action must always be equal and contrary to reaction; or the action of two bodies upon each other must be equal and directed towards contrary sides.

Mechanics, in Cab. Cyc. pp. 30, 38—46. Prof. Whewell's Bridg. Treat. p. 232. Mechanics, by Laplace, Toplis, 1814, p. 2. New Treat. on Mechanics, London, 1841, p. 1.

72. That when a body has a motion of rotation, the line round which it revolves is called an *axis;* in which case every point in the body must move in a circle whose centre lies in the axis, and whose radius is the distance of the point from it. That, sometimes, when the body revolves, the axis, itself, is moveable, and, not unfrequently, in a state of actual motion; the motions of the earth and planets being examples of this kind.

Mechanics, in Cab. Cyc. pp. 128, 129. New Treat. on Mechanics, London, 1841.

73. That the same causes which produce pressure on a body when restrained, will produce motion if the body be free. Accordingly, if a body be moved by any efficient cause, it will, by reason of the CENTRIFUGAL FORCE, FLY OFF; and the moving force with which it will thus retreat from the centre round which it revolves will be the measure of the centrifugal force. The following are the expressions of its laws:—

1. Equal weights revolving with the same velocity at equal distances from the centre will have the same centrifugal force.
2. Equal weights with equal angular velocities, at distances from the centre in the proportion of one to two, have their centrifugal forces in the same proportion.
3. Equal weights at equal distances, with velocities as one to two, have their centrifugal forces as the square of their angular velocities.
4. Equal weights at distances as two is to three, and with velocities as one to two, have their centrifugal forces in the proportion of their respective distances multiplied by the square of their velocities. And
5. Weights which are as one to two at equal distances, with the same velocity, will have their centrifugal force increasing as the mass of the moving body increases.

Mechanics, in Cab. Cyc. pp. 98—101, 105. Mechanics, by Laplace, Toplis, pp. 49—52. New Treat. on Mechanics, pp. 73—84. Whitehurst's Theory of the Earth, pp. 9—11.

74. That to the centrifugal force, arising from the rotation of the earth around its axis, and to its greater opposition to gravity in the equatorial regions, is attributed the protuberance of its form in those regions: or the excess of the equatorial beyond the polar diameter. And that this opinion is corroborated by the excessive oblate form, and corresponding rotatory velocity of Jupiter. The axis of the planets in general being less than the diameters perpendicular to the axis.

Mechanics, in Cab. Cyc, p. 105, et seq. System of Astronomy, by Margaret Bryan, 1797, p. 27, et seq. Connexion of the Sciences, pp. 8, 34—36, 76. Whitehurst's Theory of the Earth, 1786, pp. 9—14. Astron. by Sir John Herschel, pp. 108—123. Phillips's Geology, p. 7. Phen. and Order of the Solar System, p. 224.

75. That forces, in general, are classed according to the duration of their action into *instantaneous* and *continued;* the effect of the former being produced in an infinitely short time. If the body which sustains it be previously quiescent and free, it will move with a uniform velocity in the direction of the impressed force; but if the body be so restrained that the impulse cannot put it into motion, then the fixed points or lines which resist the motion will receive a corresponding shock, called *percussion,* at the moment of the impulse; and which, like the force that caused it, is *instantaneous.*

A continued force will produce a continued effect, with corresponding results.

Mechanics, in Cab. Cyc. pp. 129—131. Daniel's Philos. of Chemistry, p. 15.

76. That if a point on which a force be applied is free to move in a certain direction not coinciding with the applied force, it will be resolved into two elements, one of which will be in the direction in which the point is free to move, and the other at right angles to that direction. The point will move in obedience to the former element, and the latter will produce percussion or pressure on the point or line which restrains the body.

And, that should the forces impressed on the body, whether continued or instantaneous, be such as, were it free, would communicate to it a motion, which the restraining circumstances do not forbid it to receive, then the fixed points or lines which restrain the body sustain no force; the phenomena will be the same, in all respects, as if those points or lines were not fixed.

Mechanics, in Cab. Cyc. pp. 130, 131.

77. That if a solid body, movable on a fixed axis and susceptible of no motion, except one of rotation on that axis, be submitted to the action of instantaneous force, one or other of the following effects must ensue:—

1st. The axis may resist the force and prevent any motion.

2nd. The axis may modify the effect of the force, sustaining itself a corresponding percussion; and the body will receive a motion of rotation; or,

3rd. The force applied may be such as would cause the body to revolve round the axis, even were it not fixed; in which case the body will receive a motion of rotation, but the axis will suffer no percussion.

That the same results proceed from the application of continued forces:—

1st. The axis may entirely resist the effects of continued forces, and suffer a percussion which can be estimated by the rules for the composition of forces.

2nd. It may modify the effect of the applied forces, and sustain a pressure; the body receiving a motion of rotation, subject to constant variation, owing to the incessant action of the forces; or

3rd. The forces may be such as would communicate to the body the same rotatory motion if the axis were not fixed; in which case the forces will produce no pressure on the axis.

Mechanics, in Cab. Cyc. pp. 129—132.

78. That when a solid body revolves on its axis all its parts are whirled round together, and each performing a complete revolution in the same time; consequently, the angular velocity is the same for all. The tendency of each particle to fly from the axis, arising from the centrifugal force, is resisted by the cohesion of the parts of the mass, and, in general, the tendency is expended in exciting a pressure or strain upon the axis, whose amount depends upon the figure and density of the body, and the velocity of its motion.

That the following forms of solid bodies are exempted from any strain upon the axis during rotation, namely, a globe revolving on any of its diameters, the densities being the same at equal distances from the centre; a spheroid, or a cylinder revolving on its axis, the densities being equal at equal distances from the axis, and

That since no pressure is exerted on the axis, the state of the body will not be changed if, during the rotation, the axis ceases to be fixed. The

body will continue, notwithstanding, to revolve round the axis, and the axis will retain its position.

Mechanics, Cab. Cyc. pp. 129—131, 140—142.

79. That the power of a force to produce rotation is accurately estimated, not by the force alone, but by multiplying the distance of the direction of the force from the axis (called the leverage) by the force itself, the product of which is an important datum in mechanics, and is called the *moment* of the force around the axis. And, that if the *moment*, or sum of the *moments* of the forces which tend to turn a body in one direction be equal to the *moment* or sum of the *moments* of forces which tend to turn it in the opposite direction, they will mutually neutralize each other and produce equilibrium.

Mechanics, in Cab. Cyc. pp. 133—136. Connexion of the Sciences, p. 82. Mechanics, by Laplace, Toplis, pp. 69, 70. New Treat. on Mechanics, London, 1841.

80. That if the force applied to a body be directed upon the axis, and at right angles to it, no rotatory motion will be produced.

If a sphere, at rest in space, receive an impulse passing through its centre of gravity, all its parts will move with an equal velocity in a straight line. And, that if the impulse does *not* pass through the centre of gravity, its particles having unequal velocities, will have a rotatory or revolving motion at the same time that it is translated in space.

Mechanics, in Cab. Cyc. p. 133. Connexion of the Sciences, p. 9.

81. That there is a certain point called the *centre of gyration*, at which, if the whole mass were concentrated, it would receive from an impulse the same velocity round the axis. And, that the perpendicular distance from the centre of gyration to the axis is termed the *radius of gyration*.

That of all axes, taken in the same body parallel to each other, *that* which passes through the centre of gravity has the least *radius of gyration*. That the product of the numerical expression for the mass of the body and the square of the radius of gyration is called the *moment of inertia*. That the velocity of rotation which a body receives from any given impulse is great in exactly the same proportion as the *moment of inertia* is small.

And, that from all these principles it follows, *that a given impulse at a given distance from the axis will communicate the greatest angular velocity when the axis passes through the centre of gravity*.

Mechanics, in Cab. Cyc. pp. 136—138. Mechanics, by Laplace, Toplis, 1814, pp. 208, 209.

82. That the point of a plane where the direction of an impressed force meets it when no percussion on the axis is produced is called the *centre of percussion*.

That there are many positions of an axis which may have no *centre of percussion*—that is, there will be no direction in which an impulse could be applied without producing a shock upon the axis.

That one of these positions is when it is a principal axis passing through the centre of gravity; and as this is the only case of rotation round an axis in which the latter will sustain no pressure from the centrifugal force of the revolving mass, it follows, *that the only case in which the axis sustains no effect from the action produced, is one in which it necessarily must suffer an effect from that which produces the motion*.

Mechanics, in Cab. Cyc. pp. 139—145.

83. That in FRICTION the amount of the resistance increases according to the roughness of the surfaces, and the force with which these, moving upon one another, are pressed together. Surfaces being equal, a double pressure will produce a double friction. That these results are but slightly affected by the velocity with which the surfaces move upon each other.

And, therefore, any body moving under the effects of a given force will, in proportion to the increase of the asperity and pressure, be the more speedily deprived of its velocity, and reduced to a state of rest. That FRICTION is a great source of heat independently of fire or flame; and that it also excites electrical influences.

Mechanics, in Cab. Cyc. pp. 260—268. Playfair's Hutt. Theory, p. 186. Nat. Philos. by Sir John Herschel, pp. 313—330. Prof. Whewell's Bridg. Treat. pp. 238—250. Chemisty, in Cab. Cyc. p. 42. Heat, in idem, pp. 27, 385—403. Electricity, in idem, pp. 230—232, 259—261. vol. ii. p. 283. Daniel's Philos. of Chemistry, pp. 47, 60, 99—101. New Treat. on Mechanics, London, 1841, p. 2.

84. That the ATMOSPHERE is an aerial ocean surrounding the earth in all directions, and of which the surface of the land and sea forms the bed. That its density diminishes with extreme rapidity as it proceeds upwards; and, eventually, at a height not exceeding fifty miles, reaches a real and definite boundary. That this upper surface is estimated to be precisely where the specific elasticity of the air is balanced by the power of gravitation. And, that the mean temperature of space is considered to be 58° below the zero point of Fahrenheit.

Astronomy, by Sir John Herschel, Cab. Cyc. pp. 23, 26. System of Astronomy, by Margaret Bryan, 1797, p. 73, et seq. Art. by Dr. Woolaston, in Edin. Phil. Jour. No. XIII. Note, by Mr. Smith, in same periodical, No. XVI. p. 416. Connexion of the Sciences, pp. 121, 133—136. Chemistry, by Hugo Reid, p. 37. Dick's Christian Philos. p. 106. Phillips's Geol. pp. 23, 24. Chemistry, in Cab. Cyc. p. 94. Heat, in idem, p. 234. Daniel's Philos. of Chemistry, pp. 33, 58, 174, 324. Nat. Philos. in Cab. Cyc. by Sir John Herschel, p. 231. Espy on Philosophy of Storms, 1841. Prin. of Meteorology, by G. Hutchinson, pp. 3, 4, et seq. Meteorology, by Dr. Thomson, 1849, pp. 2—27, 71, 96. Manual of Barometers, by J. H. Belville, Greenwich, 1849.

85. That the ATMOSPHERE is composed of aerial fluids, chiefly oxygen and nitrogen, in the ratio of one volume of the former to four of the latter; or, more correctly, one hundred parts of atmospheric air contain 20 2-10ths of oxygen and 79 8-10ths of nitrogen. It also contains variable quantities of carbonic acid gas and of aqueous vapour. That the two first of these have never either been liquidized or rendered incandescent; while the amount of moisture varies according to the dew point and state of the barometer. That although in certain states it is 815 times lighter than water, it exerts a pressure on the surface of the earth equal to 15lbs. for every square inch: a pressure which prevents the sun's rays from converting water and all other fluids into vapour. That it is permanently elastic, its tension increasing in proportion to its density; admits of considerable variation in the quantity of its associated watery vapour; and, that a gas and a vapour, occupying the same space, have a tension equal to their combined tensions.

Heat, in Cab. Cyc. pp. 220, 221. Connexion of the Sciences, p. 133, et seq. Chemistry, by Hugo Reid, pp. 28—83. Dick's Christian Philos. pp. 107, 108. Prof. Whewell's Bridg. Treat. pp. 96—110. Chemistry, in Cab. Cyc. pp. 99, 103, 145—151. Heat, in idem, pp. 167, 177, 179, 356. Daniel's Philos. of Chem. pp. 33, 42, 76, 308, 314—316, 318, 319, 338, 349. Espy on the Philos. of Storms, 1841. Prin. of Meteorology, by G. Hutchinson, pp. 4, 5, et seq. Meteorology, by Dr. Thomson, 1849, pp. 2—18, 23, 24. Manual of Barometers, by John H. Belville, Greenwich, 1849.

86. That every gas has at least two ingredients in its composition, namely, some gravitating matter, which may be called its base or principal

part, and the subtile fluid, caloric or heat, and perhaps light and electricity; which, when present in sufficient quantity, cause the base or radicle to appear in a gaseous form.

Chemistry, by Hugo Reid, pp. 101, 102. Brooke's Elements of Crystalography, p. xlix. Chemistry, in Cab. Cyc. p. 58.

87. That, with respect to the oxygen and nitrogen gases of the air, although the expansive principle acts powerfully in repelling from each other the particles of the same gas, it does not act between those of different gases.

That by the "diffusion principle of gases," when two are put together they will finally be arranged as if each occupied the whole space, and the other was not present; the heavier being caused to ascend, and the lighter to descend.

That this is the case with the gases of the atmosphere, and that there seems to exist a power acting upon permanent gases capable of counteracting, to a certain extent, the effects of the attraction of gravitaton, and thereby forming an exception to what has hitherto been considered a universal law.

Chemistry, by Hugo Reid, pp. 88—83. Daniel's Philos. of Chem. pp. 73—76. Chemistry, in Cab. Cyc. pp. 146—151. Heat, in idem, pp. 187, 188. Physiol. and Anatomy of Man, by Todd and Bowman, London, 1845, vol. i. p. 3, et seq.

88. That when a space is filled with a mixture of gas and vapour, these two bodies act, under changes of volume, in exactly the same manner as they would if each separately occupied the whole space; the gas dilates and contracts, changing its pressure and temperature with its density.

The vapour obeys the same law, so long as no part of it is condensed into a liquid; but as compression renders condensation more easy by the more rapid development of heat, when much compression is used, a portion of the caloric necessary to maintain the vapour in the aeriform state will escape. A corresponding quantity of the vapour will become liquid; and the remainder will be mingled with the gas, having the same tension which it would have if the gas were not present.

Heat, in Cab. Cyc. pp. 221, 225, 226. Prof. Whewell's Bridg. Treat. pp. 86—88, 96—110. Daniel's Philos. of Chem. pp. 73—75. Meteorology, by Dr. Thomson, 1849, pp. 7, 97, et seq.

89. That a Liquid is a body, in which the attraction of cohesion is so far overcome as to admit of its yielding to the slightest pressure; and of the particles easily changing their relative position with respect to one another without separating the mass, or repelling each other as those of aeriform substances do. That fluids have a direct tendency to find and maintain their level, owing to the combined results of gravitation (whereby each particle is attracted to the centre of the earth), and the perfect mobility of the particles among themselves. And that liquids possess the property of transmitting pressure on every direction, each pressing equally on all the particles that surround it, and being equally pressed upon by them.

Disc. on Nat. Philos. by Sir John Herschel, pp. 231—234. Hydrostatics, in Cab. Cyc. pp. 4—12, 26—30, 52. Connexion of the Sciences, pp. 118, 119. Chemistry, by Hugo Reid. Mechanics, by Laplace, Toplis, 1814, p. 125, et seq.

90. That in every fluid the particles which are beneath sustain the pressure of those above them in proportion to their perpendicular depth, uninfluenced by the size or shape of that which contains the fluid. That

the pressure exercised by water is estimated at nearly one pound on each square inch for every two feet of depth. And, that of all the various states of liquidity, WATER is that which has become the general type; and to which all others are referred.

Hydrostatics, in Cab. Cyc. pp. 23—29.

91. That the great *Reservoir* of WATER, from which all other kinds are, in the first instance, derived, is the ocean, which, extending over three-fourths of the surface of the globe, affords an inexhaustible supply.

That, by repeated analyses, sea water has been found to consist of the following ingredients in every 500 grains, namely:—

478.420 of pure water
13.300 muriate of soda, or culinary salt
2.333 sulphate of soda
0.995 muriate of lime
4.955 muriate of magnesia.

Wherefore, the ocean, besides the elements of pure water,* contains muriatic and sulphuric acids, soda, magnesia, and lime, together with traces of iodine, bromine, and, occasionally, potash. That its specific gravity is to that of pure water as 1.0277 is to 1. And that the solution of salts or of acids in water increases the power of that liquid for the transmission respectively of heat, or of the electric fluid.

Chemistry, by Hugo Reid, pp. 115—120. Connexion of the Sciences, pp. 227, 228, 230, 231. Geol. by de la Beche, p. 3. Prof. Buckland's Bridg. Treat. vol. i. p. 557. Prof. Whewell's Bridg. Treat. p. 53. Chemistry, in Cab. Cyc. pp. 122—125. Heat, in idem, pp. 200, 251. Daniel's Philos. of Chem. pp. 319, 372, et seq. Principles of Meteorology, by Hutchinson, p. 17, et seq. Meteorology, by Dr. Thomson, 1849, Introduction.

92. That the water of the Caspian Sea, the Lakes of America, and of most other natural inland reservoirs of the world, is fresh; and not saline like that of the ocean.

Any geographical work.

93. That the watery vapour of the atmosphere is due to the influence of HEAT; which, infusing the repulsive principle into the waters of the seas, rivers, and lakes, causes them to ascend in an aeriform state.

That the ocean undergoes a continual process of evaporation, and dismisses into the atmosphere a quantity of pure water, proportionate to its extent of surface, to the temperature of the air, and to its state of saturation.

That whenever the temperature of the air is reduced below the limit at which the suspended vapour is maintained in a state of saturation, condensation takes place, and rain or aqueous clouds are produced.

And, that by these alternate processes the terraine surface of our globe is supplied with fresh moisture, and with water necessary to sustain the organization, and to maintain the functions of the animal and vegetable kingdoms.

Chemistry, by Hugo Reid, pp. 53, 115—117. Lyell's Prin. of Geol. vol. i. p. 269. Prof. Whewell's Bridg. Treat. pp. 53, 87, 96—110, 211—214, 228—235. Heat, in Cab. Cyc. pp. 211—214, 228—235, 249, 250. Prof. Buckland's Bridg. Treat. vol. i. p. 557. Espy on the Philos. of Storms, 1841. Vindiciæ Geol. p. 13. Phillips's Geol. p. 13. Chem. in Cab. Cyc. p. 150. Daniel's Philos. of Chem. pp. 149, 156, 160. Prin. of Meteorology, by G. Hutchinson, pp. 9—18, et seq. Manual of Barometers, by Belville, Greenwich, 1849. Meteorology, by Dr. Thomson, 1849, p. 97, et seq.

94. That the following seem to be the most obvious principles, whose

* One part hydrogen, 8 parts oxygen.

combinations and mutual action on each other govern and modify the meteorological state of the atmosphere, namely:—

The existence of a *constituent temperature* for the maintenance of water in a state of vapour. The opposite tendencies of *air* from the colder to the warmer parts; and of *vapour* from the warmer to the colder parts of the atmosphere and terraqueous surface. The different rates at which the temperature and tension of air and of vapour decrease as they ascend from the surface of the earth or sea. The different capacities for heat of those two component parts of the earth's surface. And, lastly, the unequal distribution of the electric fluid in the nephalic masses of the atmosphere, and its tendency to a state of equilibrium.

Prof. Whewell's Bridg. Treat. pp. 86—112. Whitehurst's Theory of the Earth, 1786, p. 148, et seq. Daniel's Essay on Meteorology. Phillips's Geol. p. 13. Heat, in Cab. Cyc. pp. 65, 211—214. Daniel's Philos. of Chem. pp. 157, 286. Espy on the Philos. of Storms, 1841. Prin. of Meteorology, by Hutchinson, Introd. Manual of Barometers, by Henry Belville, Greenwich, 1849. Meteorology, by Dr. Thomson, Glasgow, 1849.

95. That the Vaporization of a *Fluid* is accelerated by the increase of its temperature, and more so when heat is applied to a surface free from external pressure; in a vacuum vaporization is almost instantaneous. The agitation of the surface likewise increases the effect. That, in general, the rate of evaporation from the surface of the water, in all states of the atmosphere, will be proportioned to the tension of vapour which would saturate the atmosphere, diminished by the tension of the vapour actually in the atmosphere.

And that, as different substances are subject to vaporization at different temperatures, this peculiarity is frequently employed in chemistry and the arts as an efficacious method of precipitating solutions by separating them from the water with which they are combined.

Chemistry, by Hugo Reid, p. 53. Connexion of the Sciences, pp. 241, 242, 248, 250. Heat. in Cab. Cyc. pp. 18, 146—149, 154—175, 200—223, 227—232, 238—244, 263. Prof. Whewell's Bridg. Treat. pp. 86—88. Prin. of Meteorology, by Hutchinson, pp. 26, 89, et seq. Chemistry, Cab. Cyc. p. 150. Daniel's Philos. of Chemistry, pp. 139—141, 149—151, 154, 318, 319. Espy on the Philos. of Storms, 1841. Meteorology, by Dr. Thomson, 1849, p. 97, et seq.

96. That the comparatively feeble affinity of Water for bodies—which is sufficient merely to dissolve them without materially altering their properties, or retaining them in too firm chemical union—constitutes one of its chief advantages: various solid bodies, when dissolved, manifesting properties which would not otherwise have been discovered; but by its means, the cohesion of their particles being overcome, and being, by this simple carrier (water), brought into close and universal contact with their particles, they are rendered more capable of chemical combination.

That *Water*, by its dissolving power, enables one substance to be separated from another, or from a number of other bodies with which it may be associated. And that the properties of water, with relation to light, heat, and electricity, render it the fittest agent which can be employed in conducting chemical operations.

Chemistry, by Hugo Reid, pp. 109—111, 139. Phillips's Geology, p. 202. Chemistry, in Cab. Cyc. pp. 7, 364, 389—391. Heat, in Cab. Cyc. pp. 348, 387. Hydrost. in Cab. Cyc. p. 3. Daniel's Philos. of Chem. pp. 69—71, 129, 319, 441, 450, 525—532. Electricity, in Cab. Cyc. vol. ii. p. 392. Prin. of Meteorology, by Hutchinson, p. 160, et seq. Connexion of the Sciences, pp. 227 231. De Luc's 2nd and 3rd Letters. Pop. Hist. of Brit. Algæ, pp. 60—62.

97. That geologists generally concur in the opinion that the sea is the residium of a primitive ocean, which, at one time or other, seems to have covered the dry land which now constitutes the habitable surface of the

globe. That from it were deposited the mineral ingredients which compose the inorganic portion of the stratiform masses of the earth. That this separation simultaneously prepared the primitive ocean for becoming the present sea. And, lastly, it has been maintained, especially by some of the earlier geologists, "That there are no operations now taking place in the sea, which bear the slightest analogy to those productions of mineral substances in strata which took place formerly on our globe."

Phillips's Geology, pp. 54, 95, 207. Whitehurst's Theory of the Earth, 1786, pp. 15—27, 86. Chemistry, by Hugo Reid, p. 120. Letter by Dr. Fleming, in Edin. Phil. Jour. No. XV. p. 121. Geol. by Dr. M'Culloch, vol. i. p. 497. Vestiges of Creation, p. 73. Fowne's Actonian Prize Essay. Daniel's Philos. of Chem. pp. 445, 446. De Luc's Letters. Ancient World, by Ansted, 1847, p. 108, et seq.

98. That EARTHY MATTER consists generally of some metallic substance in chemical combination with oxygen, forming an oxide. That the combination of earthy metals with oxygen usually takes place when favoured by a sufficient elevation of temperature. That this constitutes the important change which many metals undergo when heated under exposure to the air. And that, to facilitate this combination, it is necessary to raise their temperature considerably, to some metals it being even requisite to apply very intense heats.

Chemistry, by Hugo Reid, p. 144. Brooke on Crystalography, pp. xlviii. liv. Chemistry, by Dr. J. Murray, vol. ii. pp. 123, 124. Chem. in Cab. Cyc. pp. 115—120. Electricity, in Cab. Cyc. p. 179. Daniel's Philos. of Chemistry, p. 420, et seq.

99. That the great mass of mineral matter which constitutes the crust of the globe is composed of the following substances, namely:—

1. Silex, or flinty earth; 2. Alumina, or earth of clays; 3. Lime; 4. Magnesia; 5. Soda; 6. Potash; 7. Iron, chiefly as an oxide; 8. Baryta; 9. Strontia; 10. Glucina; 11. Yttria; 12. Thorina; and 13. Zirconia.

Chemistry, by Hugo Reid, pp. 147—167. Dr. Ure's Chem. Dict. pp. 408, 409. Elements of Chem. by Dr. Murray, vol. ii. pp. 64—68, 123—125. Geol. by Dr. M'Culloch, vol. i. p. 194. Prof. Buckland's Bridg. Treat. vol. i. p. 69. Prof. Phillips's Geol. pp. 27—29, 45, 46. Lyell's Elem. of Geol. vol. i. p. 22. vol. ii. pp. 196—211, 226—333. Heat, in Cab. Cyc. p. 126. Chemistry, in idem, pp. 115—120. Electricity, in idem, pp. 172—179.

100. That LIME is never found pure in nature; but exists always in chemical combination with other substances, chiefly carbonic acid, in which state it is so abundant as to compose about 1-8th of the entire crust of the globe. It is also very abundant as a sulphate; as a phosphate it constitutes 86 per cent. of the bones of animals and of men. And in various saline combinations, especially as a muriate, it exists in the waters of the ocean, in that of springs, and in vegetable and animal matter. It is considered by many to be the product of animal secretion. And possesses the singular quality of being much more soluble in *cold* than in *hot* water.

Murray's Elements of Chem. vol. ii. pp. 81—89. Chemistry, by Hugo Reid, pp. 105, 150, 155—157. Dr. Ure's Chem. Dict. pp. 246, 247. Brooke's Crystal. pp. xlix.—lvii. Geol. by Dr. M'Culloch, vol. i. pp. 202, 216, 221, 237. vol. ii. pp. 256, 257, 262, 413. Prof. Buckland's Bridg. Treat. vol. i. p. 577. Lyell's Elem. of Chem. vol. i. p. 23. Chem. in Cab. Cyc. pp. 32, 118, 119.

101. That by experiment it has been proved, that if carbonate of lime be heated under a pressure equal to 1,700 feet of sea water; or to a column of liquid lava 600 feet high, so as to prevent the escape of its carbonic acid, it may be melted at a temperature even not higher than 22° of Wedgewood's scale. That by this process it acquires considerable hardness and closeness of texture, approaching, in these qualities, as well as in fracture and specific gravity, to the finer kind of limestone or marble. And latterly it has been discovered, that even without compression car-

bonate of lime may be fused by the sudden application of violent heat, or by submitting it to heat in a large mass.

Lyell's Prin. of Geol. vol. iii. p. 370. Elem. of Chem. by Dr. Murray, vol. ii. p. 85. Dr. Buckland's Bridg. Treat. vol. i. p. 41. Lyell's Elem. of Geol. vol. i. p. 106. vol. ii. pp. 258—260, 406. Phillips's Geol. pp. 76, 259. Disc. on Nat. Philos. by Sir John Herschel, pp. 269, 270.

102. That Carbonic Acid abounds in nature, and appears to be produced under a variety of circumstances. It composes 44-100ths of the weight of limestone, marble, calcareous spar, and other natural varieties of calcareous earth. That on the application of a pretty strong heat to the various kinds of limestone (carbonate of lime), the carbonic acid is evaporated and the *lime* remains.

And, that the basis of all effectual cements used in constructing works designed to be either occasionally or permanently under water, must be made from the hydrate of lime.

Dr. Ure's Chem. Dict. pp. 25—27, 585. Chemistry, by Hugo Reid, pp. 151—157. Lyell's Elem. of Geol. vol. i. pp. 25, 26. Chem. in Cab. Cyc. pp. 33, 118, 119, 257. Optics, by Sir D. Brewster, Cab. Cyc. p. 144. Daniel's Philos. of Chem. pp. 326, 356.

103. That *Quartz* consists almost entirely of silica, with a little alumina and oxide of iron.

That *Felspar* in 100 has 63 parts of silica, 17 alumina, 13 potash, 3 of lime, and 1 oxide of iron.

That *Mica* is composed of 46 parts of silica, 31 of alumina, 8.50 potash, 8.50 oxide of iron, 1.50 oxide of manganese, the remainder fluoric acid and water. That *Hornblend* has silica 42, alumina 12, oxide of iron 30, lime 11, magnesia 2.25, and the rest manganese.

That *Steatite* consists of 64 parts silica, magnesia 22, water 5, and oxide of iron 3. That common *Limestone* is composed of 56 parts of lime and 44 of carbonic acid. That *Earthy Chlorite* has 43 per cent. oxide of iron, 26 of silica, 18 of alumina, magnesia 8, and muriate of soda 2 per cent. That *Gypsum* (selenite) consists of 33 parts lime, 46 sulphuric acid, and of water 21 parts; and that *Rock Salt* contains in 1,000 parts, 983 of muriate of soda, 6 parts sulphur of lime, the remainder being insoluble matter.

From which analyses it is obvious that silica, alumina, lime, magnesia, potash, soda, and the oxides of iron and manganese, are, by far, the most abundant ingredients in the rocky parts of the earth, appearing to compose about 99-100ths of the entire mass of the outer crust of our planet. Whilst baryta, strontia, glucina, yttria, zirconia, and thorina, though occasionally found, are thus shown to be of comparatively rare occurrence.

Chemistry, in Cab. Cyc. pp. 33, 115, 120, 232. Lyell's Elem. of Geol. vol. i. pp. 90, 381. vol. ii. p. 205, and tables, pp. 210, 328, 381. Chemistry, by Hugo Reid, pp. 147—157. Phillips's Geol. pp. 25—29. Brooke's Crystalography, pp. xlviii.—lxiv.

104. That, in order to form a just idea of Soil—which consists of small stones and sand, impalpable earthy matter, decaying animal and vegetable substances, and small quantities of salts—it is necessary to conceive different rocks to be decomposed and ground to fineness, some of their soluble parts dissolved in water, and *that* water adhering to the mass, and the whole mixed with the remains of vegetables and animals in different stages of decay, together with small portions of salts; the earthy matter, however, constituting their chief proportion. And that, when the mineral ingredients of soils are traced to their ultimate elements, they are found to consist chiefly of silica, alumina, magnesia, and the oxides of iron and of manganese.

Chem. by Hugo Reid, pp. 158—167. Dr. Ure's Chem. Dict. pp. 156—161, 736, 757—759. Whitehurst's Theory of the Earth, pp. 217—219. Geology, by Dr. M'Culloch, vol. i. p. 11. Agricult. Chemistry, by Sir H. Davy. Prof. Buckland's Bridg. Treat. vol. ii. pp. 69, 70. Lyell's Elem. of Geol. vol. ii. p. 188. Vindiciæ Geol. p. 17. Chemistry, in Cab. Cyc. pp. 115—120. Botany, in idem, pp. 176, 299.

105. That METALLIC ORES—which are metals in combination either with sulphur, charcoal, oxygen, and even with other metals, or with silica, alumina, and lime—are commonly found in narrow fissures, termed lodes or veins, predominating in the primitive and transition series, and which are usually filled up with some crystaline mineral different from the rock in which they occur.

That they are supposed to have been produced by electrical agency developed by the violent contact and friction of rocks of various kinds containing, previously, metalliferous elements. And, that the same lode frequently contains a metallic pyrite, and, within a short distance, separated merely by a common argillaceous substance, some other modification of the same metal, whilst the lode itself is generally saturated with water containing various salts.

Lyell's Elem. of Geol. vol. ii. pp. 342, 363. Werner on Veins. Transactions of British Association, at Bristol, 1836, Lit. Gazette. Brof. Buckland's Bridg. Treat. vol. i. pp. 548—553. vol. ii. p. 108. Prof. Whewell's Bridg. Treat. p. 114. Chemistry, by Hugo Reid, p. 166. Phillips's Geol. pp. 111, 112. Electricity, Cab. Cyc. pp. 169—172. Daniel's Philos. of Chemistry.

106. That when a general view is taken of METALLIC VEINS on any geological map, the following prominent and characteristic features present themselves to the observation, namely:—

1. That they either entirely originate from, or predominate in the primary masses and the transition series.

2. That, generally, they run in straight lines, and in directions oblique to the surface; veins of different materials cutting each other at right angles, and, not unfrequently, perpendicular to the lines of stratification.

3. That, unlike *faults* and *dykes*, *mineral veins* do not cause dislocation of the strata; but seem, whilst they have evidently passed through, to have left them undisturbed in their relative positions. And

4. That when veins cut each other at right angles they are usually different in their contents.

Prof. Buckland's Bridg. Treat. vol. i. pp. 458—555. vol. ii. pp. 147—149, map and notes. Lyell's Elem. of Geol. vol. ii. on metals in veins. Phillips's Geol. pp. 84, 91, 111, 112, 263—276. Vindiciæ Geologici, pp. 18—21. Geology, by H. T. de la Beche, pp. 521—524.

107. That COAL—of which there are two principal species, black and brown, and several sub-species, all varying in the proportion of their elementary constituents—is generally admitted to be of *vegetable* origin; and, although consisting essentially of carbonaceous matter, yet there is frequently present a soft, bituminous substance, which communicates to it peculiar properties. That, on being distilled, it affords a considerable quantity of ammonia. And it is thought that pressure and the continued action of water have been the principal agents in transforming the original vegetable matter into bituminous coal.

Dr. Ure's Chem. Dict. pp. 339—341. Chem. by Hugo Reid, p. 157. Prin. of Geology, by Lyell, vol. ii. p. 216. Botany, in Lib. Useful Know. Murray's Elem. of Chem. vol. ii. p. 368. Vestiges of Creation, p. 80. Botany, by Prof. Henslow, Cab. Cyc. p. 310. Geol. by Dr. M'Culloch, vol. ii. pp. 350—353, 358, 414. Prof. Buckland's Bridg, Treat. vol. i. pp. 64, 454—459. Lyell's Elem. of Geol. vol. ii. pp. 106, 279—281.

108. That NATIVE SALTS, such as saltpetre *(nitrate of potash)*, green vitriol *(sulphate of iron)*, rock salt *(muriate of soda)*, sal ammonia *(muriate*

of ammonia), borax, or tincal *(biborate of soda)*, alum *(sulphate of alumina and potash)*, and natron *(carbonate of soda)*, are found fossil in the earth in regular and symmetrical crystaline forms. And, that they yield rapidly to any force applied to them, and are capable of being fused by heat.

Chemistry, by Hugo Reid, p. 142. Dr. Murray's Elem. of Chemistry, vol. ii. pp. 289—291. Mineralogy, by Prof. Jamieson, vol. iii. pp. 1—45. Murchison's Geol. Invest. in Russia, Poland, &c. Chemistry, in Cab. Cyc. p. 114. Daniel's Philos. of Chemistry.

109. That, in chemical language, ALKALIES are bodies which, besides possessing other minor properties, combine with acids, so as to neutralize and impair their activity. That METALLIC OXIDES are metallic substances combined with oxygen without being in a state of an acid. That the characteristic and indispensable property of an *Acid* is to unite in definite proportions with the *Alkalies*, *Earths*, and *Metallic Oxides*, and form thereby the important class of substances called *Salts*. That "*a salt*," therefore, denotes a compound in definite proportions of acid matter with an alkali, earth, or metallic oxide; and that the carbonates, sulphates, muriates, &c., of soda, lime, and magnesia, &c., are formed by the union of these acids with the bases which give them their respective denominations.

Dr. Ure's Chem. Dict. pp. 5, 135, 673, 709, et seq. Dr. Murray's Elem. of Chem. vol. ii. p. 70, et seq. Chemistry, by Hugo Reid. Chemistry, in Cab. Cyc. pp. 101, 109—113, 121. Daniel's Philos. of Chemistry, pp. 431, 445—449.

110. That besides pure water the most common ingredients in mineral springs are carbonic acid, sulphuretted hydrogen, carbonates, sulphates, and muriates of soda, of lime, and of magnesia, and carbonate and sulphate of iron. And those of more rare occurrence are sulphurous acid, nitrogen gas, sulphate of alumina, muriate of manganese, siliceous earth, fluoric acid, lithnia, strontia, potash, and hydriodic acid.

That as mineral contents are in chemical solution, they rarely, even when in great abundance, affect the clearness of the water. That to hold a large quantity of silex in solution, it seems requisite that the water should be raised to a high temperature. And that, notwithstanding their mineral character and the high temperature of some of the springs, confervæ and other plants thrive in and close around them.

Dr. Murray's Elem. of Chemistry, vol. ii. p. 376. Chemistry, by Hugo Reid, pp. 133—137. Lyell's Prin. of Geol. vol. i. pp. 227—243. Geol. by H. T. de la Beche, pp. 139—147. Botany, by Prof. Henslow, Cab. Cyc. p. 173. Lyell's Elements of Geology, vol. i. pp. 67, 89, 381. vol. ii. p. 407. Phillips's Geology, p. 147. Gardiner's Essay on Mineral and Thermal Springs.

111. That when substances are rendered fluid, with perfect mobility amongst their particles, either by igneous fusion or by solution, and are suffered to pass with adequate slowness into the solid state, the attractive forces—called homogeneous attraction—frequently re-arrange these particles into regular polyhedral figures or geometrical solids; to which the name of CRYSTALS has been given. That mere approximation of the particles is not, however, alone sufficient to produce *crystalization*, they must also change the direction of their poles from the fluid collocation to their position in the solid state, which may be effected by the following means, namely:—

1. By vibratory motion, communicated either from the atmosphere or any other moving body.
2. By contact of any part of the fluid with a point of a solid of similar composition previously formed, or other substance.

3. By the slow and continued agency of voltaic electricity operating in water.

That darkness, in most instances, favours crystalization.

That heat, likewise, exercises considerable influence on these phenomena; and, lastly, that the same substance, in crystalizing, not unfrequently assumes a diversity of forms; though, in general, the same substance, under similar circumstances, assumes the same form.

Disc. on Nat. Philos. by Sir John Herschel, pp. 239—246, 290—293. Lyell's Elem. of Geol. vol. i. pp. 76—89. vol. ii. pp. 390—400. Daniel's Philos. of Chem. pp. 78—99, 603. Chemistry, in Cab. Cyc. pp. 17—19. Heat, in idem, pp. 195—199. Brooke on Crystalography. Prof. Buckland's Bridg. Treat. vol. i. p. 36. Vestiges of Creation, p. 170. Connexion of the Sciences, pp. 124—128, 312. Dr. Ure's Chem. Dict. pp. 379, 380. Transactions of Brit. Asso. Sept. 1836. Electricity, in Cab. Cyc. vol. ii. pp. 379—386. Botany, in Cab. Cyc. p. 6. Mechanics, in Cab. Cyc. pp. 14, 15.

112. That most of the rocks which compose the mineral crust of the earth are in a crystalized state. *Granite*, for example, consisting of crystals of quartz, felspar, and mica; *Marble* of crystals of carbonate of lime, &c. And that the whole phenomena attendant on crystalization go to prove that substances having the same crystaline form must consist of ultimate atoms, having the same figure and arranged in the same order, so that the form of crystals is dependent on their atomic constitution.

Geology, by H. T. de la Beche, pp. 486—511, et seq. Lyell's Elem. of Geol. vol. ii. pp. 390—400. Geology, by Dr. M'Culloch, vol. i. pp. 122, 123. Brooke on Crystalography, pp. xlviii.—lxiv. Dr. Ure's Chem. Dict. pp. 379—381. Connexion of the Sciences, pp. 124—128. Chemistry, by Hugo Reid, pp. 147—157. Prof. Buckland's Bridg. Treat. vol. i. pp. 574—579. Heat, in Cab. Cyc. p. 186. Daniel's Philos. of Chem. p. 78, et seq. Prof. Phillips's Treatise, pp. 69—80.

113. That ever since Botany has merited the name of a science, there has been a difference in the opinions of its followers as to the principles which ought to govern the systematic classification of the interesting objects to which it relates. And even in the present day, while the *Linnæan* and *natural* methods mutually diffuse light on each other, they resist a thorough and cordial reconciliation. That the *Linnæan* system is founded chiefly on the leading distinctions of *phanogamian* and *cryptogamian* construction, and the varied relations of certain parts of the floral organs of the former division; whilst the *natural* system is based not only on these characteristics, but, likewise, on a comparison of the internal structure, nutritive organs, method of vegetation, and seeding processes of the various plants composing the vegetable kingdom, all of which are, by it, resolved into three classes, namely: Acotyledons, Monocotyledons, and Dycotyledons.

Botany, by Prof. Henslow, Cab. Cyc. pp. 30, 136—155. Flora Scotica, by Sir William Jackson Hooker. Botany, in Pop. Encyclo. pp. 638—640. Botany, in Lib. Useful Know. pp. 14—18. General Review of Living Beings, Edin. Jour. Nat. Hist. p. 18.

114. That the Acotyledonous or Cryptogamous Class includes an extensive series of plants, grouped under several Orders, differing considerably in many particulars, but the whole agreeing in the important circumstance of *never bearing flowers*. That, having no flowers, they produce no true seeds, but, in lieu thereof, the higher tribes are furnished with minute granular bodies, capable of becoming distinct plants, called sporules; not separable into distinct parts with radicle, plumule, and cotyledons, like the seeds of phanogamian plants.

That these sporules possess the power of producing from any part, either stem or root, as circumstances may require, while it is quite otherwise with

true seeds. That acotyledonous plants increase acrogenously, and, as a class, they consist of the following orders, namely:—

I. Fungi; II. Lichens; III. Algæ; IV. Characeæ; V. Hepaticeæ; VI. Musci; VII. Filices; VIII. Lycopodineæ; IX. Marciliaceæ; X. Equisetaceæ.

Flora Scotica, by Hooker, part ii. pp. 3—161. Botany, by Prof. Henslow, Cab. Cyc. pp. 11, 17, et seq. Botany, in Lib. Useful Know. p. 108. Edin Review, No. XCIX. p. 154. Connexion of the Sciences, p. 456. General Review of Living Beings, Edin. Jour. Nat. Hist. p. 18. Philos. of Plants, by Decandolle and Sprengel. Prof. Buckland's Bridg. Treat. vol. ii. p. 453. Lyell's Elem. Geol. vol. i. p. 67. De Luc's Letters, pp. 110, 157, et seq. Pop. Hist. Brit. Algæ, by Dr. Landsborough.

115. That considerable difference of opinion prevails respecting the classification of the Cryptogamic plants, owing to the great dissimilarity between the higher and the lower tribes of the class. The former—contained in the division "Ductalosæ"—having green expansions, much resembling leaves in their general appearance, and possessing stomata, but differing from them in other respects, especially in bearing the fructification upon their fronds; whilst the lower tribes of cryptogamic plants—included in the group called "Cellulares"—are homogeneous in their structure, with nutritive organs not distinguishable into roots and leaves, and many of them parasytic; seldom green, and without stomata.

Botany, by Prof. Henslow, Cab. Cyc. pp. 27, 76, et seq. Mosses, by Dr. George Gardiner, 1839. Classification, by Sir William Hooker, compared with those by Decandolle and Sprengel, and by M. Cuvier.

116. That in the Monocotyledons—consisting of several orders—there is no distinction between the pith, the wood, and the bark, but their stems consist, generally, of a cylindrical, though sometimes of an angulated mass of cellular tissue, in which are bundles of vascular tissue without medullary rays. That they are called *Endogenæ*, from the newly-formed material developing itself towards the innermost part of their stems. That an albuminous mass forms the main bulk of most of the monocotyledonous seeds, having the embryo placed within it; the general character of these seeds being that of a cylindrical body tapering towards the extremities, from one of which, in due time, protrudes the radicle, and from the other arises a single, conical, and almost solid cotyledon.

Flora Scotica, by Sir W. J. Hooker, pp. 161—194. Botany, by Prof. Henslow, in Cab. Cyc. pp. 33, 43, 49, et seq. Botany, in Lib. Useful Know. pp. 9—24, 55—57. Smith's Intro. to Botany, p. 59. Edin. Jour. Nat. Hist. p. 18. Philos. of Plants, by Decandolle and Sprengel. Prof. Buckland's Bridg. Treat. vol. ii. p. 453. Connexion of the Sciences, p. 282.

117. That the Dicotyledonous Class is distinguished by the existence of pith in the centre of the stem, by increasing *exogenously*, that is, by fresh material being yearly arranged externally between the former wood and bark, and by medullary rays proceeding from the centre to the circumference of their woody parts.

That the seeds are furnished with two fleshy lobes called "*Cotyledons*," attached to a rudimentary germ concealed between them; the cotyledons during the first stages of germination becoming imperfect leaves to protect the plumule and to nourish the young plant until the radicle be developed into a root; and, finally, that this natural order comprises the more perfect plants and trees, and those whose internal structures and component tissues are most complex.

Flora Scotica, by Sir W. J. Hooker, pp. 194—297. Botany, by Prof. Henslow, Cab. Cyc. pp. 31—33. 43, 62, et seq. Botany, in Lib. Useful Know. pp. 9—24, 55. Edin. Jour. of Nat. Hist. p. 18.

Philos. of Plants, by MM. Decandolle and Sprengel. Prof. Buckland's Bridg. Treat. vol. i. p. 453. Connexion of the Sciences, p. 282.

118. That all the phenomena attending the flowering of plants, and the dehiscence of the various receptacles which are instrumental in the fertilization and maturation of the *seed* and *fruit*, and the dissemination of the former, fully attest the absolute necessity of *these complicated operations being conducted in atmospheric air;* the presence of much moisture being prejudicial to the peculiar development of the pollen.

Botany, by Prof. Henslow, Cab. Cyc. pp. 50, 79—110, 195, 263—268, et seq. Botany, in Library of Useful Know. pp. 38—42, 108. Prof. Whewell's Bridg. Treat. pp. 19, 23—25, 27, 47—49, 51. Any other Botanical Treat. Nat. Syst. Hunt, on Light, pp. 181—202. Lindley and Hutton's Fossil Flora, vol. i. p. xv. Pop. Hist. Brit. Algæ, by Rev. Dr. Landsborough, 1849.

119. That immediately after the flower has become fully expanded, some portions of it begin to decay; but the ovarium, and sometimes the calyx, and other parts continue to grow, and assume a very different appearance—they become the FRUIT; while the ovula, having been subjected to the fertilizing influence of the pollen, also undergo certain remarkable changes, and become the SEED.

That these fruits, thus enclosing their seeds, assume a great variety of forms and characters, some being soft and pulpy, others hard, woody, dry, and membranaceous; but in general, they may be classed under some one or other of the following denominations, namely:—the legume; the drupe; the nut; the akenium; the glans; capsule; gourd; berry; pome; samara, or the siliqua.

Botany, by Prof. Henslow, Cab. Cyc. pp. 102—109. Botany, in Lib. Useful Know. pp. 47—52. Any other Treatise on Botany, or on Horticulture.

120. That, according to the opinions of the most eminent botanists, it is light, heat, water, and air, and the conjoint action of the first three of these upon the irritable membranes, which enable plants, by virtue of their extensibility, elasticity, and hydrometrical powers to perform the phenomena of contraction and endosmose; by means of which they absorb and digest their food, circulate their fluids, develope their organs, increase in size, and reproduce themselves.

Botany, in Cab. Cyc. by Prof. Henslow, pp. 170—184, 190—203, 293—295, 298. Botany, in Library Useful Know. pp. 81, 84. Prof. Whewell's Bridg. Treat. pp. 115, 116. Daniel's Philos. of Chem. pp. 460—462. Connexion of the Sciences, p. 279. Hunt, on Light, p. 200. Lindley and Hutton's Fossil Flora, vol. i. p. xv. Physiol. and Anat. of Man, by Todd and Bowman, London, 1845, vol. i. p. 13, et seq.

121. That the time required to admit of plants arriving at maturity varies from some months to several years. And that vegetation exerts a conservative influence in protecting land from denudation by water, it being well known that a covering of herbage and plants protects a loose soil from being carried away by heavy rains, or even by the ordinary action of a river.

Botany, by Prof. Henslow, in Cab. Cyc. pp. 238, 239. Prin. of Geol. by Mr. Lyell, vol ii. pp. 204—209. Prof. Whewell's Bridg. Treat. p. 27.

122. That of all organized substances, plants are, perhaps, the most susceptible of modification in their nature and characteristic properties by the influence of climate, soil, and other circumstances.

"A bitter maritime plant having, by these means, been metamorphosed into two distinct species of garden vegetables as unlike each other as each is to the parent plant."

That although these are extreme cases, and not strictly within the limits of causes purely natural, where extent of change has a more restricted limit, still it is admitted that considerable alterations can be effected on plants in a state of nature by modifications of soil and climate.

Prin. of Geol. by Mr. Lyell, vol. ii. pp 32—36, 50. Botany, in Cab. Cyc. by Prof. Henslow, pp. 190, 294, 309. Old Red Sandstone, Miller, Edin. 1841, pp. 39, 40.

123. That roots and seeds will not vegetate unless they be placed only at a limited depth beneath the surface of the ground. That the roots and stems of almost all plants develope themselves in opposite directions—the latter having a tendency to grow *upwards*, whilst the former goes *downwards*.

And that there can be no doubt but a direct connexion exists between "gravity" and "light," and these tendencies which the roots and stems of plants, generally, manifest of growing in opposite directions.

Botany, by Prof. Henslow, in Cab. Cyc. pp. 10, 280—293. Chemistry of Nature, by Hugo Reid. Turner's Sacred History, pp. 127—135, founded on Mr. Porteun's assertion.

124. That, besides the carbonic acid elaborated by plants within themselves by means of the oxygen imbibed from the atmosphere and by the carbonaceous matter contained in their sap, they absorb it also from the air, and receive it combined with the water taken in by their spongioles.

That so long as plants remain in the dark the greater part of the carbonic acid is retained, but not fixed in the form of an organic compound until stimulated by the light, when its decomposition is effected; the carbon becomes fixed, and nearly all the oxygen with which it was united, is exhaled into the atmosphere.

Botany, by Professor Henslow, Cab. Cyc. pp. 175, 184—191, 201, 202. Dr. Ure's Chem. Dict. p. 26. Botany, in Library of Useful Know. pp. 79—90. Prof. Whewell's Bridg. Treat. pp. 115—117. Daniel's Phil. of Chem. pp. 315—318. Physiol. and Anatomy of Man, by Todd and Bowman, London, 1845, vol. i. p. 22, et seq.

125. That Fossil remains of Vegetation are abundant in many geological formations, but especially in the *Coal Measures;* and that the periods of the formations, thus abounding in fossilized relicts of vegetation, have been grouped into the following four grand epochs, namely:—

1. From the earliest secondary rocks to the uppermost beds of the coal measures; in which upwards of three hundred distinct species have been recognised; the higher tribes of the cryptogamous plants comprising about two-thirds of the whole number.

2. The New Red Sandstone series; affording only a few species of fossil plants.

3. From the lowest beds of the oolitic series to the chalk, inclusive. The few species found in the green sandstone and chalk being chiefly of marine origin; and

4. The beds above the chalk, where dicotyledons begin to prevail, and plants of terrestrial, lacustrine, and marine species entirely different from those of the previous divisions. While the fruits which have been found are referable to existing genera.

Botany, by Prof. Henslow, in Cab. Cyc. pp. 310—314. M. Adol. Brongniart on Fossil Vegetation. Fossil Flora, by MM. Lindley and Hutton. Prin. of Geol. by Mr. Lyell, vol. i. p. 169. Elem. Phil. of Plants, by MM. Decandolle and Sprengel, pp. 276, 277. Manual of Geol. by H. T. de la Beche, pp. 413, 430, et seq. Edin. Jour. Nat. Hist. p. 58. Prof. Buckland's Bridg. Treat. pp. 63, 453, 463, 490—523. Athenæum, No. 985. Ancient World, by Ansted, London, 1847. Phillips's Geology, pp. 289, 290.

126. That the result of investigations into Fossil Flora have led eminent geological naturalists to the following conclusions respecting the three great geological periods, namely:—

1. That during the First or Transition epoch, which includes the Coal Measures, there was a predominance of vascular cryptogamia, and a comparative rarety of gymnospermous phanerogames.

2. In the second, an approximation to equality of vascular cryptogamia, and of dicotyledons, composed entirely of gymnospermous phanerogames.

3. In the Tertiary, a predominance of dicotyledons, and paucity of vascular cryptogamic plants. And

4. That during each of these three periods remains of monocotyledonous plants occur, although sparingly.

Prof. Buckland's Bridg. Treat. vol. i. p. 520. Botany, by Prof. Henslow, in Cab. Cyc. pp. 310—314. Lyell's Elem. of Geol. vol. i. p. 285. Vestiges of Creation, pp. 88—94.

127. That although the fragments of fossil vegetables often possess great beauty, and their tissue may be distinguished under a microscope as completely as in recent species; yet, in general, the remains of ancient plants are not so perfectly preserved as the skeletons of animals or the coverings of mollusca; those parts (the flowers and seeds) upon which the distinction of species and their classification chiefly depend, being very rarely met with and most frequently detached. And that, as it is principally from these imperfect remains that a comparison between the ancient and present flora can be instituted, such data are by no means adequate to ensure an accurate determination of specific differences, although they afford means of ascertaining truths of high interest.

Under such circumstances it has been agreed to refer the fossil vegetable remains to *genera* whose names are modifications of the recent genera.

Botany, by Prof. Henslow, in Cab. Cyc. pp. 18, 310—314. Edin. Jour. Nat. Hist. p. 23. Phillips's Treat. on Geol. p. 286. Ancient World, by Ansted, p. 80. Vestiges of Creation, pp. 84—88. Fossil Flora, by Lindley and Hutton, vol. i. Introduction.

128. That when the principle of life has departed from vegetable substances exposed to the atmosphere, they begin spontaneously to decompose, and their remains, entering into new combinations, form carbonic acid, water, carbonic oxide, and carburetted hydrogen; these modifications continuing until nothing remains but the saline, earthy, and metallic substances originally contained in the vegetable matter. But when the exclusion of the atmosphere and considerable pressure take place, the former circumstance removing the agency of oxygen, and the latter preventing the formation of elastic products, the decomposition does not proceed beyond the accumulation of a carbonaceous residium; from which it is probable have been derived the several varieties of bitumen and coal.

Chemistry, by Hugo Reid, pp. 178—180. Elem. of Chem. by Dr. Murray, vol. ii. p. 570. Chemistry, in Cab. Cyc. pp. 33, 286, 342. Botany, by Prof. Henslow, in Cab. Cyc. pp. 7, 14. Physiol. and Anatomy of Man, by Todd and Bowman, London, 1845, vol. i. pp. 10—12, et seq.

129. That all material substances may be classed under two divisions: Organised and Unorganised. That the want of organization is the peculiar characteristic of mere inert matter, affords an evidence of the absence of the living principle, and proves that it never has been present in these bodies; while the slightest trace of organization discoverable in any natural body is a complete proof that life is, or at least once was, present in it.

That organized beings have been subdivided by universal consent from the earliest ages into ANIMALS and PLANTS; the latter possessing only the simpler powers of vegetation; and that, notwithstanding this classification, it is extremely difficult, and has hitherto baffled the attempts of naturalists to point out the precise limits which separate these two kingdoms of organized existences.

Animal Kingdom, by Cuvier, Edin. Jour. Nat. Hist. pp. 3—5. Botany, by Prof. Henslow, Cab. Cyc. pp. 5—8. Chemistry, by Hugo Reid, pp. 169—172. Mechanics, in Cab. Cyc. p. 30. Architecture of the Heavens, pp. 119, 120. Old Red Sandstone, Miller, Edin. p. 43. Physiology and Anatomy of Man, by Todd and Bowman, London, 1845, vol. i. pp. 3—21, et seq. Dr. Pring on the Laws of Organic Life.

130. That the ANIMAL KINGDOM, from the most perfect of its beings down to the verge of that indistinct line where it comes into contact with the vegetable kingdom, may be comprised within two grand divisions, namely, *Vertebrate* and *Invertebrate*. The former being provided with a skull and vertebral column for the protection of the brain and spinal marrow; the latter being destitute of both of these defences.

And that all the beings comprising the *first* great division, when in their perfect state, possess the faculty of voluntary motion; while amongst the invertebrate, although there are some species likewise possessed of the power of locomotion, and others which are endowed with it in a limited degree, there are many which soon become fixed to external substances, and remain, during the whole period of their natural existence, in that condition.

Cuvier's Animal Kingdom, Edin. Jour. Nat. Hist. pp. 13, 18, 19. Hist. of British Animals, by Dr. Fleming, pp. 2, 46, 129. Philos. of Zoology, by idem. Botany, by Prof. Henslow, Cab. Cyc. pp. 5—8, 155—168. Old Red Sandstone, by H. Miller, Edin. 1841. Physiol. and Anatomy of Man, by Todd and Bowman, London, 1845, vol. i. p. 4, et seq.

131. That all the INVERTEBRATE *animals* which have not the power of locomotion are natives of the water, whose fluctuations continually bring new objects into contact with their organs of sensation, and by that means supply them with food; and that, although it is difficult to draw a line of distinction between those which are endowed with the faculty of voluntary motion and those which are not, yet such a distinction does actually exist, and is, therefore, capable of being delineated.

Philos. of Zoology, by Dr. Fleming, vol. i. pp. 46, 129. Vestiges of Creation, pp. 247—260. Cuvier's Animal Kingdom, Edin. Jour. Nat. Hist. Physiology and Anatomy of Man, by Todd and Bowman, London, 1845, vol. i. p. 67, et seq.

132. That, with a very few exceptions, the organised existences classed under the denominations of *Zoophyta,* the whole of the *Crinoideæ* and *Blastoideæ,* and among the *Mollusca,* the *Acephala, Brachiopoda,* and *Cirrhopoda* must be considered as fixed to one spot during the whole of their perfect existence.

Philos. of Zoology, by Dr. Fleming, vols. i. and ii. History of British Animals, by idem. General Review of Living Beings, Edin. Jour. Nat. Hist. p. 19. Prof. Buckland's Bridg. Treat. vol. i. p. 417. Ancient World, by Ansted, pp. 38, 92—95. Vestiges of Creation, pp. 178, 203.

133. That scarcely any fact in experimental geology is better established than "that the generations of organized bodies which have successively inhabited the progressive surface of our globe, differ from the present generation in proportion as their exuviæ are farther removed from its actual surface; or, in proportion as the period during which they lived is more remote from the present time."

That there is not a single instance on record amongst geological data to

warrant the assumption that any species, once extinct, ever was re-created during a succeeding period of the ancient world; and that *producta, trilobites, spirifer, orthoceratites, ichthyolites, ammonites, belemnites*, and numerous others of similar category are examples of organized marine bodies having become extinct.

Jamieson's Cuvierian Theory, pp. 336—338. Foss. Organic Remains, by M. Adol. Brongniart, in No. XVI. Edin. Phil. Jour. pp. 226—230. Geol. Essay on Superposition, by Humboldt, pp. 48, 57. Nat. Philos. by Sir John Herschel, Cab. Cyc. pp. 282—284. New Walks in an Old Field, Miller, 1841. Conchol. by Capt. Brown, pp. 58—65. Hist. of British Animals, by Dr. Fleming, pp. xiv.—xviii. Manual of Geol. by H. T. de la Beche, p. 193, et seq. Lyell's Prin. of Geol. vol. i. p. 82. vol. ii. p. 133. vol. iii. pp. 59, 253, 254. Prof. Buckland's Bridg. Treat. vol. i. pp. 62, 113. Ansted's Ancient World, London, 1847, pp. 54—56. Lyell's Elem. of Geol. vol. i. pp. 10, 199—211. Phillips's Geol. pp. 51, 107, 287—289. Vestiges of Creation.

134. That the remains of plantæ, zoophyta, and testacea, are not more profuse and extensive throughout the fossiliferous formations up to the chalk, than the non-appearance of vestiges of true birds is remarkable; and that no fragment of a quadruped bird or reptile has yet been obtained from any of the carboniferous strata in any part of the world.

Lyell's Prin. of Geol. vol. i. p. 171. vol. ii. p. 254. vol. iii. p. 253. Edin. Jour. Nat. Hist. pp. 12, 62. Prof. Buckland's Bridg. Treat. vol. i. pp. 85, 86. Lyell's Elem. of Geol. vol. i. p. 355. Phillips's Geology, p. 289. Ancient World, by Ansted, pp. 90, 91, 206. Vestiges of Creation, Table of Classification. Old Red Sandstone, by H. Miller.

135. That when the Author of Nature creates an animal or plant, all the possible circumstances in which its descendants are destined to live are foreseen, and a corresponding organization is conferred upon it to enable the species to perpetuate itself as long as is consistent with His omniscient purposes under all the circumstances to which it will inevitably be exposed.

Lyell's Prin. of Geol. vol. ii. p. 24. Manual of Geol. by H. T. de la Beche. Prof. Whewell's Bridg. Treat. p. 18. Geology, by H. T. de la Beche, pp. 476, 477. New Walks in an Old Field, Miller, 1841. Lyell's Elements of Geology, vol. ii. pp. 435, 436. Phillips's Geol. pp. 285—290. Daniel's Philos. of Chem. pp. 324, 371, 372. Vestiges of Creation, pp. 164, 217—220, 331. Ancient World, by Ansted, pp. 47—51.

136. That all Fish—all that inhabit the waters, except the crustaceous and testaceous animals—are of the same specific gravity as the fluid they live in. That these classes breathe atmospheric air.

That the *molluscous* and *conchiferous* divisions of the animal kingdom possess no skeleton; their muscles being attached to the skin, which forms a soft envelope or mantle, whose most important appendix is the shell.

That this latter is secreted by the corium, and increases by coatings in the inner surface, being regulated in form by the body of the animal, with whose existence it is coeval, and cannot be dispensed with; and that the solid matter of the shell consists of carbonate of lime united by a small portion of animal matter resembling coagulated albumen.

Philos. of Zoology, by Dr. Fleming, vol. ii. pp. 401, 402. Cuvier's Animal Kingdom, Edin. Jour. Nat. Hist. pp. 13, 19, 25, 28. Dr. Ure's Chem. Dict. p. 741. Turner's Sacred History, pp. 195—199. Chem. by H. Reid, p. 181. Dr. J. M. Good's Stud. Med. vol. i. pp. 1—38, 494—523. Paper, by Mr. Hatchett, read before the Royal Society, 1800. Daniel's Philos. of Chem. p. 68. Lyell's Elements of Geol. vol. ii. pp. 298, 299.

137. That the evidences afforded by the examination of fossilized zoophyta, mollusca, conchifera, pisces or plantæ, seem alike to indicate the existence of some general law—pervading the primitive fluid wherein they grew and lived—which required that they should encrust themselves with some *solid intermedia* between it and their interior parts; whether these coverings assumed the character of stony particles, testaceous or conchiferous coverings, enamelled plates, vegetable tubercules, or scales, &c.

Lindley and Hutton's Fossil Flora. New Walks in an Old Field, Miller, Edin. Ancient World, by Ansted, 1847.

138. That ANIMAL RESPIRATION—which consists in the alternate inhalation of a portion of air into the lungs, its transformation there, and subsequent exhalation—occasions, by means of the diffusion principle of gases, and of membraneous endosmose, a re-invigorating interchange of gases. The oxygen of the atmosphere abstracting and occupying the place of the carbonic acid of the venous blood, which acid is exhaled in a gaseous form.

That the changes which take place in the elements concerned in the process of respiration have a relation to the elevated temperature of certain *Orders* of animated beings; and that there is, likewise, an immediate connection between the power of accelerating voluntary motion and the function of respiration, action of the lungs, and the circulation of the blood.

Murray's Intro. to Chem. vol. ii. pp. 588—591. Dr. J. M. Good's Stud. Med. pp. 494—523. Botany, by Prof. Henslow, Cab. Cyc. p. 187. Chemistry, by Hugo Reid, pp. 57, 58, 61—64. Edin. Jour. Nat. Hist. pp. 24, 25. Dr. Ure's Chem. Dict. p. 704. Chemistry, in Cab. Cyc. pp. 317—322, 329, 332. Heat, in idem, pp. 389—391. Daniel's Philos. of Chem. p. 318. Botany, in Cab. Cyc. pp. 156, 157, 187, 236. Hunt on Light, pp. 199—201. Meteorology, by Dr. Thomson, 1849, pp. 14, 15, 19—21. Physiol. and Anatomy of Man, by Todd and Bowman, 1845, vol. i. pp. 3, 24, et seq.

139. That on the decomposition of animal substances taking place, when moisture and a certain degree of heat is present, putrefaction commences, the elements of the animal matter enter into new combinations, and generally pass off in the gaseous form; ammonia being always disengaged in considerable quantity; phosphuretted, sulphuretted, and carburetted hydrogen, and carbonic acid are likewise separated, and only an inconsiderable portion of earthy matter remains when the process is finished.

Murray's Elements of Chemistry, pp. 655, 676, 677. Dr. Ure's Chem. Dict. pp. 112—117, 695, 696. Chemistry, by Hugo Reid, pp. 180, 181. Chemistry, in Cab. Cyc. pp. 131, 145, 301, 338—340, 342, 343. Daniel's Philos. of Chem. pp. 324, 371, 603, 641—645, 677. Old Red Sandstone, by H. Miller, 1847. Physiol. and Anatomy of Man, by Todd and Bowman, London, 1845, vol. i. pp. 4, 10, 12, et seq.

APPENDIX B.

CLASSIFICATION OF INVERTEBRATE ANIMALS—BRITISH TYPES.

The following are the essential outlines of the particulars given by Dr. Fleming in his Treatise on British Animals of the GASTEROPODA, exclusive of the *Pulmonifera*,* namely—

SECT. II. GASTEROPODA.—***Organs of progressive motion fitted for creeping.***

DIVISION II. BRANCHIFERA.—***Respiring in water.***

TRIBE I. NUDIBRANCHIA. ***Marine.***

Genus—Doris, Policera, Tergipes, Tritonia, Montagna, Eolida, Valvata, Patella, Chiton.
TECTIBRANCHIA.—Applysia, Pluerobranchia, Bulba.

TRIBE II.—PECTINABRANCHIA.

DIVISION—CRYPTOBRANCHIA.

HOLOSTOMATA.
TURBONIDÆ.—**Marine.*—Turbo, Phasianella, Turritella, Cingula, Odostomia, Monodonta, Scalaria, Cyclostrema, Delphinula, Cirus, Skenea, Euomphalus.
****Fluviatile.*—Paludina, Ampullaria, Melania.
NERITADÆ.—**Marine.*—Nerita, Natica.
****Fluviatile.*—Neritina.
TROCHUSIDÆ.—Trochus, Solarium, Janthina, Velutina.

DIVISION I.—SOLENOSTOMATA.

A. CONUSIDÆ.—Conus, Terebellum, Seraphs.
B. CYPRÆADA.—Cypræa (Cypreovula).
C. OVULADÆ.—(Ovula), Volva, Calpurna.
D. VOLUTADÆ.—Voluta, Volvaria, Mitra, Cancellaria.
E. MARGINELLADÆ.—Marginella, Columbella.
F. OLIVADÆ.—Oliva, Ancillaria.
G. TORNATELLADÆ.—Tornatella, Acteon.
H. BELLEROPHON.—Bellerophon.

DIVISION II.—***Shell turrited, whorls sub-conical, slightly embracing.***

BUCCINIDÆ.—Cassis, Morio, Nasa, Ricinula, Purpura, Monoceras (Concholepas), Harpa, Dolium, Buccinum, Eburnea.

PECTINABRANCHIA.

MURICIDEÆ.—Turbinella, Fasciolaria, Terebra, Pyrula, Fusus, Pleurotoma, Ranella, Murex, Typhis, Triton.
CERITHIADÆ.—**Marine.*—Cerithium, Strutheolaria.
****Fluviatile.*—Potamedum, Melanopsis (Pirena).
STOMBUSIDÆ.—(Stombus), (Pterocera), Rostellaria.
SCRUTIBRANCHIA.—*I. Shell ear-shaped.*—Haliotis (Padola), (Stomatia).
II. Shell oblong, or conical.—Crepidulidæ.

* These enumerations are almost exclusively restricted to the names of *Genera*, to admit of comparison with those discovered fossil in the strata.

**Marine.*—Plate of the cavity spirally decurrent. Calyptrœa, Infundibulum, Crepidula, Pileolus.
***Fluviatile.*—Navicella.
CAPULIDÆ.—Capulus (Carinaria).
FISSURELLADÆ.—Fissurella, Emarginula, Scissurella.*

The following are the particulars given by the same indefatigable naturalist, of the Mollusca *Acephala*, and *Branchiopoda;* which are transcribed in continuation of the division of the *immovable* "creature that hath life."

MOLLUSCA. ACEPHALA.

ORDER II.

MOLLUSCA. ACEPHALA.—Destitute of a distinct head or neck; no rudiments of organs of hearing and sight: organs of the two sexes incorporated in the same individual.

SECTION I.

CONCHIFERA.—Covering testaceous.

DIVISION I.

BRANCHIOPODA.—All the species are marine, and permanently attached.
PEDUNCULATA.—Lingula, Tesebratula, Spirifer, Magas.
SESSELIA.—Discina, Criopus, Pentamerus, Productus.

DIVISION II.—BIVALVIA.

ASIPHONIDA.—*I. Valves closed by one abductor muscle.*
A. Shell free, or adhering to other bodies by byssus.
PECTONIDÆ.—Shell compact.—Pecten, Lima, Plagiostoma, Pedum. Shell foliated.—Gryphæa, Vulsella, Placuna.
PERNADÆ.—Perna, Gervillea, Crenatula, Inoceramus, Malleas.
AA. Shell fixed or cemented to other bodies.
OSTREADÆ.—Ostrea, Hinnites, Dianchora, Anomia.
SPONDYLIDÆ.—Spondylus, Plicatula.
II. Valves closed by two abductor muscles.
A. *Hinge with teeth.*
ARCADÆ.—Arca, Cucullea, Pectunculus, Nucula.
TRIGONIADÆ.—Trigonia, Castalia, Avicula.
AA. *Hinge without teeth.*—Meleagrina, Pinna.
SIPHONIDÆ.—Cloak more or less closed, forming syphons.
I. One syphon only.
A. *Shell transverse.*
MYTILIDÆ.—Mytilus, Modiolus, Lithodomus.
UNIONIDÆ.—*Hinge simple.*—Anodon (Iridina).
Hinge with teeth.—Unio, Alismadon.
AA. *Shell with prominent beaks.*
CARDITADÆ.—Cardita, Venericardia, Crassatella.
II. Cloak closed anteally and retrally, with three openings towards the middle of the ventral margin. TRIDACNADÆ.
III. Cloak open anteally.
A. *Shell ear-shaped.* CHAMADÆ. Chama, Diceras, Etheria. CARDIADÆ. Isocardia, Hippopodium, Cardium, Pholadomya, Cypricardia.
AA. *Shape various.* CORBULADÆ. Corbula, *Equivalve.* MACTRADÆ. Mactra, Goodallia, Lepton, Kellia, Loripes, Ervillia, Amphidesma.
Ligament external. DONACIDÆ. Donax, Capsa, Tellina.
No lateral teeth. Psammobia, Astarte, Lucina, Myrtea.
Three teeth at least. CONQUES of Lamark.
**Marine.* VENERIDÆ. Cyprini, Cytherea, Venus, Venerupis.
***Fluviatile.* CYCLEDÆ. Cyclas, Cyrena, Galateola.
IV. Cloak closed ventrally, &c.

* British Animals, pp. 281—366.

A. *Lodged at the extremity of a calcareous tube, with which it is more or less intimately connected.* TEREDINIDÆ. Teredo, Xylophaga, Fistulana, Clavagella.

AA. *Destitute of a secreted calcareous tube.*

PHOLADÆ.—Pholas, Gastrochæna.

SOLANIDÆ.—No accessory valves.—Solen, Sanguinolaria, Hiatella, Panopæa, Glycemeris.

MYADÆ.—Ligament internal.—Mya, Lutraria, Sphenea, Pandeora, Galeoma.

MOLLUSCA TUNICATA. DICHITONIDA. All the British Dichitonida are fixed.

A. *Body simple.*

a. Apertures furnished with four rays.—Pandocia.

aa. Apertures with indistinct rays, or more than four.

b. Body pedunculated.—Clavellina.

bb. Body sessile.—Pirena, Ciona, Phallusia.

AA. *Body compound.*

Polyzona, Sydneum, Alpidium, Botryllus.*

The necessary particulars of the Class *Cirripeda*, are taken from another work on Conchology, which, among other distinguishing characteristics, declares that all the Molluscs of this division "*are incapable of locomotion.*"†

CLASS CIRRIPEDA.—Divided by Lamark into two orders.

ORDER I.

PEDUNCULATE.—The body supported by a tubular moveable peduncle, the base of which is attached to extraneous substances in the ocean. It consists of the following genera:—

Genus.—1. Otion. 2. Cineras. 3. Pollicipes. 4. Sarpellum. 5. Anatifa.

ORDER II.

SESSILIA.—Body without a peduncle, and enclosed in a multivalve shell; seated immediately on marine bodies or rocks. It is composed of,

Genus.—1. Prygoma. 2. Creusia. 3. Acasta. 4. Adna. 5. Balanus. 6. Coronula. 7. Tubicinella.‡

And lastly, Dr. Fleming affords such a description of the *Echinodermata* and *Polypi* as the British shores afford; which, although necessarily restricted in the latter division, will yet be sufficient to convey a distinct general idea of the existences which come under these denominations.

ECHINODERMATA.

SECTION I. ORDER I.—Free.

A. ECHINIDÆ.—Covering of immovable testaceous plates, without projecting arms.

I. ANOCYSTI.—Vent in the dorsal surface.—Cidaris, Echinus, Clypeus (Cassidula, Nucleolitis).

II. PLEUROCYSTI.—Echinarachnius, Spatangus.

III. CATOCYSTI.—Echinocyamus (Echinanthus, Echinodiscus), Conulus (Echinoneus), Echinocorys.

AA. *Covering crustaceous and movable.*

FISTULIDÆ.—Holothuria, Cuvieria, Mulleria.

ASTERIADÆ.—Asterias Ophiura, Astrophyton, Comatula, Marsupites.

SECTION II.—*Destitute of suckers for locomotion.*

Sipunculus, Priapulus.

ORDER II.—Fixed.

CRINOIDÆ.—Apiocrinites, Pentacrinus, Encrinites.

* History of British Animals, pp. 367—471. † Captain Brown on Conchology.
‡ Conchologist's Text Book, p. 148.

II. Plates of the body articulating imperfectly.
Poteriocrinites.
III. Plates of the body adhering by sutures.
Cyathocranites, Caryocrinites, Actinocrinites, Rhodocrinites, Platycrinites.
IV. Plates of the body anchylosing.
Eugeniacrinites.
BLASTOIDÆ.—Margin of the oral disc destitute of arms.
Pentremites.

"The fossil remains of Crinoideasis," says Professor Buckland, "have long been known by the name of Stone Lilies or Encrimites, and have lately been classed under a separate order by the name of CRINOIDÆ.

"This order comprehends many genera and numerous species, and is arranged by Cuvier after the Asteræ in the division Zoophytes.

"Nearly all these species appear to have been attached to the bottom of the sea, or to floating extraneous bodies."*

POLYPI.

I. CARNOSA.—Polypi connected with a fleshy substance, and consisting of,

I. *Free; marine;* moving by the contraction or expansion of the fleshy part; form symmetrical; axis of the body supported by a bone contained in a sac.
Pennatula, Virgularia.

II. *Fixed or stationary.*

A. Polypiferous matter covering a solid axis; *a.* axis with stellular discs.—LAMELLILERÆ.
b. Stellular discs terminal.
Sarcinula, Lithostrotion, Caryophyllea, Turbinolia, Cyclolites.
bb. Stellular discs aggregated.
Explanaria, Astrea, Porites, Pocillopora.
aa. Axis destitute of stellular discs. *b.* Axis corneus and flexible; polypiferous basis cretaceous; the axis with spines.
c. Polypi developed.—GORGONIADÆ.
Gorgonia, Primnoa.
cc. Polypi not developed.—CORALLINADÆ.
Iania, Corallina, Halimeda.
bb. Axis stony.
Isis.

B. *Polypiferous basis* destitute of a continuous solid axis. *a.* Polypi developed.
b. With eight tentacula; the basis fibrous.
Lobularia, Cydonium, Cliona.
bb. Polypi with tentacula exceeding eight in number; basis nearly uniform.
Alsyonium, Cristatella.
aa. Polypi not developed.—SPONGIADÆ.
Tethya, Halichondria, Spongia, Grantia.

II. CELLULIFERA.

Polypi lodged in calcareous shells; imperforate at the base, and consisting of,

I. *Substance rigid stony.*
I. Cells in the form of minute pores, imbedded.—MILLEPORADÆ.
Millepora.
II. Cells tubular and produced beyond the surface.—TUBIPORADÆ.
Tubipora, Favosites, Tubulipora, Discopora, Filipora, Terebellaria.
III. Cells utricular, adjacent, or superimposed.—ESCHARDÆ.
Eschara, Retepora, Cellepora, Berenicea, Hippothoa, Alecto.
II. *Substance flexible.*—FLUSTRADÆ.
Farcimia, Flustra.

* Bridgewater Treatise, p. 417.

III. THECATA.

Polypi surrounded by a membraneous tube, covering the sub-divisions of their compound body, and consisting of,

I. *Sheath slightly calcareous; cells single, or in rows.*—CELLARIADÆ.
Cells enlarged, in rows, united or single.
Cells united, with the orifices opening on the upper surface.
Cellularia, Tricellaria, Crisia.
Cells in pairs, attached by the back, the orifices with opposite aspects.
Notamia.
Cells single.
Eucratia, Anguinaria.

II. *Sheath membranaceous, cells enlarged externally and lateral.* SERTULARIADÆ.
I. Base of the cells broad, coalescing with stem, and on opposite sides.
Sertularia, Dynamena, Thuiaria.
Cells unilateral.
Antennularia, Plumularia, Serialaria.
II. Base of the cells narrow or pedunculated.
Campanularia, Valkeria, Cymodocia.
III. Sheath membranaceous, cells simple, extremities of branches.
TUBULARIADÆ.
Tubularia, Plumatella.

IV. NUDA.

Polypi naked, the mouth with marginal tentacula.—Coryna, Hydra.

V. VIBRATORIA.

Polypi having the mouth furnished with vibrating hairs.*

APPENDIX C.

ANIMAL EXUVLÆ, IN THE DESCENDING ORDER, FROM THE CRETACEOUS GROUP.

According to the lists given in the most approved geological manuals, the following compose the animal organic remains found embedded in the rocks alluded to.† They are given in geological succession, from the chalk formations downwards; and in a consolidated abstract.

OF THE CRETACEOUS GROUP.

ZOOPHYTA.

	Species.		Species.		Species.		Species.
Achilleum . .	3	Chenendopora	1	Retepora . .	5	Ventriculites	3
Spongia . .	12	Meandrina .	1	Lunulites . .	1	Serea . . .	1
Alcyonium .	2	Nullipora . .	1	Caryophillia .	2	Eschara . .	10
Siphonia . .	2	Manon . .	5	Hippalymus .	1	Flustra . .	3
Gorgonia . .	1	Spongus . .	2	Astrea . . .	14	Orbitolites .	1
Cellepora . .	7	Choanites . .	3	Turbinolia . .	2	Fungia . .	3
Ceriopora . .	20	Hallirhoa . .	1	Scyphia . .	7	Diploctenium	2
Lithodendron	2	Millepora . .	4	Tragos . . .	5	Pagrus . .	1

* History of British Animals, pp. 472, 505—553.

† The organic remains, of a testaceous character, pertaining to the *tertiary* formations, will be found fully detailed in Mr. Lyell's *Principles of Geology*. They occupy no less than 43 pages of his Appendix, and are well worthy of being referred to.

POLYPIFERS.—*Genera not determined.*

RADIARIA.

	Species.		Species.		Species.		Species
Apiocrinites .	1	Pentacrinites	1	Cidaris . .	10		
Glenotremites	1	Galerites . .	9	Clypeus . .	1		
Asterias, not determined.							
Echinus . .	7	Nucleolites .	10	Ananchytes .	9	Echinoneus .	4
Cassidulus .	1	Clypeaster .	3	Marsupites .	1	Spatangus .	29

ANNULATA.—SEDENTARIA.

Serpula, 9 species determined, and 1 not determined.

CIRRIPEDA.

Pollicipes, 2 species.

CONCHIFERA.

Magas Pumilus
Thecidea, 3 species
Terebratula, 53 species
Crania, 8 species
Orbicula, species not determined
Sphæra Corrugata
Trigonia, 11 species, and 1 not determined
Nucula, 11 species
Pectunculus, 3 species
Arca, 6 species, and 1 not determined
Podopsis, 6 species
Spondilus ? Strigilus
Plicatula, 2 species
Pecten, 31 species, and 1 not determined
Lima Pectinoides
Plagiostoma, 15 species, and 1 not determined
Avicula Cærulescens, and another not determined
Inoceramus, 17 species, and 1 not determined
Gervillia Aviculoides, and two others
Crenatula Ventricosa
Hippurites, 7 species, and 1 not determined.
Sphærulites, 9 species
Ostrea, 19 species
Hinnites ? Dubuisoni
Exogyra, 5 species
Gryphæa, 9 species
Modiola, 2 species
Pachymya Gigas
Chama, 5 species
Cucullæa, 7 species, and 1 not determined
Cardita, 4 species, and 1 not determined
Cardium, 5 species
Venericardia, species not determined
Astarte Striata, and 1 species not determined
Pinna, 7 species
Mytilus, 4 species
Mytiloides Labriatus
Thetis, 2 species
Venus, 9 species
Lucina Sculpta
Tellina, 3 species, and 1 not determined
Corbula, 7 species
Crassitella Latissima, and another
Lutraria, 2 species, and 1 not determined
Mya, 5 species
Teredo, species not determined
Pholas ? Constricta
Fistulana Pyriformis

MOLLUSCA.

Dentalium, 5 species, and 1 not determined
Patella Ovalis, and 1 not determined
Pileopsis, species not determined
Helix Gentii
Auricula, 3 species
Melania, species not determined
Paludina Extensa
Ampullaria, 2 species, and 1 not determined
Nerita Rugosa
Natica, 2 species, and 1 not determined
Cassis Avellana
Dolium Nodosum
Eburna, species not determined
Voluta, 2 species
Nummulites, 2 species, and 1 not determined
Solarium Tabulatum ?
Cirrus, 4 species
Pleurotomaria, species not determined
Trochus, 10 species, and 1 not determined
Nautilus, 8 species, and 1 not determined
Vermetus, 4 species, and 1 not determined
Sigaretus Concavus
Delphinula, species not determined
Turbo, 4 species
Turritella, 2 species, and 1 not determined

Cerithum Excavatum, and 1 not determined
Pyrula, 2 species
Murex, 2 species
Pterocera Maxima
Rostellaria, 6 species, and 1 not determined
Strombus Papilionatus
Ammonites, 50 species
Actinocamax Verus
Scaphites, 3 species, and 1 not determined
Lenticulites, 2 species
Lituolites, 2 species
Planularia, 2 species
Nodosaria, 2 species
Belemnites, 6 species, and 1 not determined
Turrilites, 5 species, and 1 not determined
Baculites, 5 species
Hamites, 20 species
Fusus Anadratus
Miliolites, 2 species

Crustacea.

Astacus, 4 species, and 1 not determined
Pagurus Faujasii
Scyllarus Mantelli
Eryon, species not determined
Arcania, species not determined
Eytæa, species not determined
Coryster, species not determined

Pisces.

Squalus Mustelus? and Galeus?
Muræna Lewesiensis
Zeus Lewesiensis
Salmo Lewesiensis
Esox Lewesiensis
Amia? Lewesiensis
Fish, genera not determined
Fish, teeth and palates

Reptilia.

Mososaurus Hoffmanni
Crocodile of Meudon
Reptiles, genera not determined

"From an inspection of the foregoing list, it would appear that the remains of mammalia have not yet been detected in the cretaceous group."*

OF THE WEALDEN ROCKS OF ENGLAND.

Conchifera and Mollusca.

Cardium Turgidum? and 1 not determined
Unio, 5 species
Succinea?
Pinna?
Venus?
Ostrea, species not determined
Cyclas, 3 species, and 1 not determined
Paludina, 3 species
Potamides, species not determined
Melania, 2 species

Pisces.

Lepisosteris, Silurus, and remains of fish, genera not determined.

Crustacea.

Cypris Faba.

Reptilia.

Crocodilus Priscus, and a species not determined
Leptorynchus
Iguanodon
Megalosaurus
Reptiles of the genera Trionyx, Emys, Chelonia, Plesiosaurus, and Pterodactylus
Tortoise†

FOSSIL ORGANIC ANIMAL AND ZOOPHYTIC REMAINS OF THE OOLITIC GROUP.

Zoophyta.

Achilleum, 6 species
Manon, 3 species

* Manual of Geology, by H. T. de la Beche, 2nd edition, pp. 271—297.
† Manual of Geology, pp. 303—305.

Scyphia, 39 species
Tragos, 9 species
Spongia, 2 species, and 1 not determined
Alcyonium, species not determined
Fungia Orbiculites, and 1 species not determined
Cyclolites Elliptica, and 1 species not determined
Turbinolid Dispar, and 1 species not determined
Turbinolopsis Ochracea
Cyathophyllum, 2 species
Meandrina, 3 species, and 1 not determined
Ceriopora, 9 species
Agaricia, 3 species
Lithodendron, 2 species
Caryophyllia, 8 species
Anthophyllum, 3 species
Astrea, 20 species, and 1 not determined
Aulopora Compressa
Entalophora Cellarioides
Favosites, species not determined
Spiropora, 4 species
Eunomia Radiata
Crysaora Damæcornis, and another
Theonoa Chlathrata
Idmonea Triquetra
Cnemidium, 9 species
Limnorea Mammillaris
Siphonia Pyriformis
Myrmecium Hemisphæricum
Gorgonia Dubia
Millepora Dumetosa, and 6 others
Madrepora, species not determined
Eschara, species not determined
Cellepora, 2 species, and 1 not determined
Retepora?
Flustra, species not determined
Alecto Dichotoma, and 1 species not determined
Berenicea Diluviana, and 1 species not determined
Terebellaria, 2 species
Cellaria Smithii
Thamnasteria Lamoarouxii
Explanaria Mesenterina, and 1 species not determined
Polypifers, genera not determined

RADIARIA.

Cidaris, 18 species, and 1 not determined
Cidaris (spines of)
Echinus, 6 species, and 1 not determined
Galerites, 3 species
Clypeaster Pentagonalis, and 1 species not determined
Nucleolites, 6 species, and 1 not determined
Ananchytes Bicordata
Spatangus, 4 species, and 1 not determined
Solanocrinites, 3 species
Comatula, 4 species
Clypeus, 6 species, and 1 not determined
Echinites, genera not determined
Echinites (spines of)
Ophiura Milleri, and 2 others
Encrinites, 2 species
Eugeniacrinites, 5 species
Apiocrinites, 8 species
Pentacrinites, 14 species, and 1 not determined
Crinoidea, genera not determined
Rhodocrinites Echinatus
Asterias, 8 species

ANNULATA.

Serpula Squamosa, with 49 other species determined, and 1 not determined
Lumbrionia, 6 species

CONCHIFERA.

Spirifer Walcotii
Delthyris, 2 species
Terebratula Intermedia, and 56 other species
Orbicula Reflexa, 2 species, and 1 not determined
Hippopodium Ponderosum
Isocardia, 7 species, and 1 undetermined
Cardita, 3 species, and 1 undetermined
Cardium, 11 species
Lingula Beanii
Ostrea, 22 species, and 1 not determined
Exogyra Digitata? and 1 undetermined
Gryphæa, 14 species
Plicatula Spinosa
Pecten, 20 species
Plagiostoma, 17 species, and 1 undetermined
Myoconcha Crasa
Posidonia Bronni
Lima, 10 species, and 1 undetermined
Avicula, 11 species
Inoceramus Dubius
Gervillia, 7 species, and 1 not stated
Perna, 3 species, and 1 undetermined
Crenatula Ventricosa, and 1 undetermined
Trigonellites, 2 species
Pinna, 6 species, and 1 undetermined
Mytilus, 5 species, and 1 undetermined
Modiola, 19 species, and 1 undetermined
Nucula, 9 species, and 1 not determined

Pectunculus, 2 species
Arca, 6 species, and 1 not determined
Cucullæa, 13 species, and 1 not determined
Astarte, 12 species, and 1 undetermined
Venus, species undetermined
Cytherea, 4 species, and 1 undetermined
Pullastra, 2 species, and 1 undetermined
Donacites Alduini
Corbis, 2 species
Tellina Ampliata
Psammobia Lævigata
Lucina, 3 species, and 1 undetermined
Sanguinolaria, 2 species, and 1 undetermined
Corbula, 4 species, and 1 undetermined
Crassina, 7 species
Mactra Gibbosa
Amphidesma, 5 species
Lithodomus, species not determined
Chama, 2 species, and 1 undetermined
Unio, 7 species
Trigonia, 13 species, and 1 undetermined
Lutraria Jurassi
Gastrochæna Tortuosa
Mya, 8 species
Pholadomya, 16 species, and 1 undetermined
Panopæa 2 species
Pholas, 2 species

Mollusca.

Dentalium Giganteum, and Cylindricum, and 1 species undetermined
Patella, 7 species
Emarginula Scalaris
Ampullaria, species not determined
Natica, 5 species, and 1 undetermined
Nerita, 4 species
Peleolus Plicatus
Ancilla, species not stated
Bulla Elongata
Helicina, 4 species
Auricula Sedgvici
Delphinula, species not determined
Solarium, 2 species
Cirrus, 5 species, and 1 undetermined
Trochus, 21 species, and 1 undetermined
Rissoa, 4 species
Turbo, 9 species, and 1 undetermined
Phasianella, 2 species
Turritella, 5 species, and 1 undetermined
Nerinea Tuberculata, and 1 species undetermined
Cerithium, 2 species, and 1 undetermined
Planorbis Euomphalus
Melania, 4 species, and 1 undetermined
Paludina, species not determined
Pleurotomaria, 2 species
Tornatilla, species not determined
Vermetus, 2 species, and 1 undetermined
Buccinum Unilineatum, and 1 species undetermined
Myoconcha Crassus
Terebra, 4 species
Belemnites, 28 species, and 1 undetermined
Hammites, species not determined
Orthoceras Elongatum
Nautilus, 10 species, and 1 not stated
Ammonites, 172 species
Trigonellites, 4 species
Onychoteuthis Angusta
Murex, 2 species
Rostellaria, 4 species, and 1 undetermined
Pteroceras Oceani, 3 species
Actæon, 5 species, and 1 undetermined
Loligo, 2 species
Sepia Hastiformis, with remains of ink bags
Sepia, beaks or Rhyncolites

Crustacea.

Pagurus Mysticus
Eryon, 2 species
Syllarus Dubius
Palæmon, 3 species
Astacus, 3 species, and 1 undetermined
Crustacea, not yet determined

Insecta.

Insects of the Libellula family
Elytra of Coleopterous insects

Pisces.

Dapedium Politum
Clupea Sprattiformis
Fish, species not yet determined
Fish, palates and teeth
Ichthyodorulites of different kinds

Reptilia.

Pterodactylus, 7 species, and 1 unknown
Crocodilus, 2 species
Gavial, 2 species
Crocodile of Mans, and remains not determined
Tileosourus

Megalosaurus Bucklandi, and a species not known
Racheosaurus Grasilis
Geosaurus Bollensis
Plesiosaurus, 6 species, and 1 undetermined
Lacerta Neptunia
Ichthyosaurus, 4 species, and 1 undetermined
Saurian bones
Tortoise, in Stonesfield slate

MAMMALIA.

Didelphis Bucklandi.*

ORGANIC REMAINS OF THE MUSCHELKALK.

REPTILIA.

Plesiosaurus, Ichthyosaurus, and a great Saurian genus not determined.

CRUSTACEA.

Palinurus Sueurii.

MOLLUSCA AND CONCHIFERA.

Nautilus Bidorsatus
Ammonites, 3 species
Buccinum Obsoletum
Turritella Terebralis
Dentalites, 2 species
Terebratula, 4 species
Trigonia, 2 species
Mytilus, 2 species
Myacites, 4 species
Pecten Reticulatus
Ostrea Spondyloides
Cardium Striatum
Plagiostoma, 4 species
Avicula Sociales

ANNULATA.

Serpula, 2 species.

RADIARIA.

Two species of Encrinites
Ophiura, 2 species
Asterias Obtusa†

ORGANIC REMAINS OF THE RED OR VARIEGATED SANDSTONE.

"M. Elie de Beaumont notices that at Domptail (Vosges) this rock contains abundantly the casts of shells, for the greater part of the same genera, and even of the same species, as those discovered in the Muschelkalk. And M. Voltz remarks, that the red sandstone of the Vosges presents the following shells:—*Terebratula*, Trigonia, Pecten, Plagiostoma, Avicula (Mytilus), Sociales, Turritella? Natica?"‡

ORGANIC REMAINS OF THE ZECHSTEIN AND COPPER-SLATE.

REPTILIA.

Monitor of Thuringia.

PISCES.

Palæothrissum, 6 species, and one undetermined
Fish, genera not determined

MOLLUSCA AND CONCHIFERA.

Turbo?
Pleurotomaria?
Melania? 5 species
Ammonites, species not determined
Axinus Obscurus
Arca Tumida
Cucullæ Sulcata
Avicula Gryphæoides
Ostrea, species not determined
Astarte?
Producta, 7 species
Spirifer, 4 species
Terebratula, 8 species, and 1 undetermined
Modiola Acuminata, and 1 species undetermined
Mytilus Squamosus
Pecten, species not determined
Plagiostoma?
Venus?

* Manual of Geology, 2nd edition, pp. 332—380. † Ibid, pp. 393, 394.
‡ Ibid, 2nd edition, p. 395.

RADIARIA.

Cyathocrinites Planus, Encrinites, and Crinoidea; genera not determined.*

ZOOPHYTA.

Retepora Flustracea, and ditto Virgulacea; Polypifers, genera not determined.

ORGANIC REMAINS OF THE COAL MEASURES.

CONCHIFERA.

Pentamerus Knightii
Lingula Striata
Unio, 2 species
Nucula, 2 species
Vulsella Elongata and Breois
Pecten, 2 species
Mytilus Crassus
Saxicava Blainvillii
Hyatella Carbonaria
Mya, 3 species

MOLLUSCA.

Euomphalus Pentangularis
Turritella, 2 species
Bellerophon, 2 species
Orthoceratites, 5 species
Nautilus ?
Ammonites, 6 species

PISCES.

Ichthyodorulites, and fish palates.†

ORGANIC REMAINS OF THE CARBONIFEROUS LIMESTONE.

ZOOPHYTA.

Millepora, 5 species
Cellepora Urii
Retepora Elongata
Caryophyllia, 7 species
Fungites, 2 species
Turbinolia, 5 species
Cyathophyllum Excentricum
Meandrina, species not determined
Astrea, 2 species
Catenipora, 5 species
Tupipora Tubularia
Syringopora Cæspitosa
Calamopora Polymorpha
Favosites, 4 species
Lithostrotion, 3 species
Amplexus Coralloides
Polypifers, genera not determined

RADIARIA.

Pentremites, 3 species
Platycrinites, 7 species
Actinocrinites, 5 species
Milocrinites Hieroglyphicus
Potereocrinites, 2 species
Rhodocrinites Verus
Cyathocrinites, 2 species

ANNULATA.

Serpula, Lithuus, and Compressa.

MOLLUSCA.

Pentamerus, 3 species
Spirifer, 22 species
Terebratula, 25 species
Crania Prisca
Producta, 28 species
Modiola Goldfussii
Nucula Palmæ
Arca Cancellata
Chama ? Antiqua
Hippopodium Abbreviatum
Vulsella Lingulata
Ostrea Prisca
Hinnites Blainvillii
Pecten, 3 species
Mytilus Minimus
Cypricardia ? Annulata
Cardium, 3 species
Tellina Lineata
Sanguinolaria Gibbosa
Megalodon Cuculatus

CONCHIFERA.

Patella Primigenus
Planorbis Æqualis
Natica, 4 species
Melania, 2 species

* Manual of Geology, 2nd edition, pp. 397—399.

† Ibid, pp. 419, 420.

Ampullaria, 2 species
Melanopsis Coronata
Nerita, 3 species
Turbo, 5 species
Helix? Cirriformis
Turritella, 2 species
Buccinum, 5 species
Bellerophon, 8 species
Conularia, 2 species
Orthoceratites, 18 species
Pyramidella Antiqua
Delphinula, 8 species
Cirrus, 2 species
Euomphalus, 13 species, and 1 undetermined
Pleurotomaria Delphinulata
Trochus Catenulatus
Nautilus, 9 species
Ammonites, 3 species

Crustacea.

Calymene, 4 species, Asaphus Cordatus, Paradoxicus Spinulosus, Trilobites, genera not determined.

Pisces.

Ichthyodorulites, and Tritores, or fish palates.*

ORGANIC ANIMAL AND ZOOPHYTIC REMAINS OF THE GRAUWACKE GROUP.

Zoophyta.

Manon, 2 species
Scyphia, 4 species
Tragos, 2 species
Gorgonia Antiqua
Madrepora, species undetermined
Stromatopora Concentrica
Cellopora Antiqua, and 1 species undetermined
Retepora, 2 species, and one undetermined
Astrea Porosa, species undetermined
Columnaria Aveolata
Catenipora, 3 species, and 1 undetermined
Syringopora Verticillata
Tubipora, species not determined
Calamapora, 7 species
Aulopora, 4 species
Agaracia Lobata
Ceriopora Verrucosa, and 4 others
Flustra, species not determined
Anthophyllum Bicostatum
Turbinolia, species not determined
Cyathophyllum Dianthus, and 16 other species
Strombodes Pentagonus
Lithodendron Cæspitosum
Caryophillia, species not determined
Favosites, 5 species
Mastrema Pentagona
Amplexus Coralloides, and 1 species undetermined

Radiaria.

Actinocrinites, 7 species, and 1 undetermined
Cyathocrinites, 4 species, and 1 undetermined
Platicrinites, 4 species
Rhodocrinites Verus, and 4 others
Sphæronites, or Echinosphærites, 4 species
Penticrinites Prisus
Cuprosocrinites, 2 species
Milocrinites, 2 species
Euglinacrinites Mespiliformis
Eucalyptocrinites Rosacius

Annulata.

Serpula, 4 species

Conchifera.

Thecidea? Antiqua
Spirifer, 18 species
Terebratula, 23 species
Strygocephalus, 2 species
Calceola, 2 species
Strophomena, 6 species
Producta, 12 species
Gryphæa, species not determined
Pecten and 2 not determined
Plagiostoma, species not determined
Megalodon Cucullatus
Trigonia, species not determined
Cardium, 6 species
Cardita, 4 species
Isocardia, 2 species
Cypricardia?
Posidonia Becheri

* Manual of Geology, 2nd edition, pp. 421—429.

MOLLUSCA.

Patella, species not determined, and 3 more in doubt
Peleopsis Vetusta
Melanopsis Coronata
Melania, 2 species
Natica, species undetermined
Nerita, species undetermined
Solarium Fasciatum
Cirrus Acutus
Pleurotomaria Cirriformis
Delphinula Æquilatera
Turritella Abbreviata, and 1 undetermined
Murex? Harpula
Buccinum, 4 species
Bellerophon, 8 species, and 1 undetermined
Orthoceratites, 29 species, and 1 undetermined
Cyrtoceratites, 4 species
Eumophalus Catillus, and 3 others, and 1 undetermined
Trochus Ellipticus
Turbo Bicarinatus, and 2 others
Conularia, 3 species, and 1 undetermined
Lituites, 2 species
Nautilus, 9 species (3 are called *Ellipsolites* by Sowerby)
Ammonites, 3 species, and 1 undetermined

CRUSTACEA. TRILOBITES.

Calymene, 13 species
Asaphus, 16 species
Oxygia, 4 species
Paradoxides Tessini, and 4 others
Nileus Armadillo, and Glomerinus
Illænus, 3 species
Ampyx Nasutus
Olenus Bucephalus
Agnostus Pisiformis
Isotelus, 2 species
Trilobites, species not determined

PISCES.

Ichthyodorulites, Fish bones and a tooth; and casts referable to vertebræ of fish.*

"Even yet," says Mr. Hugh Miller, "after many thousand Trilobites have been carefully examined, it remains a question with the oryctologist, whether this crustacean of the earlier period was furnished with legs, or creeped on an abdominal foot like the snail."†

APPENDIX D.

FOSSIL VEGETABLE EXISTENCES, FROM THE CHALK DOWNWARDS.

Vegetable Organisms in the Chalk and other formations, in the descending series, viz.:—

CONFERVÆ.

Confervites fasciculata, C. ægagropiloides, species not determined.

ALGÆ.

Fucoides orbignianus, F. strictus, F. tuberculosus, F. difformis, F. intricatus, F. Lyngbianus, F. Brongniarte, F. Targioni, F. canaliculatus, F. furcatus, F. Stokii, F. encelioide, F. Brardii, F. Selaginoides, F. lycopodioides, F. frumentarius, F. pectenatus, F. Digitatus, F. antiquus, F. circinatus, and species not determined.

NAIADES.

Zosterites Cauliniæfolia, Z. liniata, Z. Bellovisana, Z. elongata.

* Manual of Geology, 2nd edition, pp. 455—469.

† New Walks in an Old Field, p. ix.

Cycadeæ.*

Cycadites Nelsonii.
Pterophyllum Williamsonis.
Zamia Pectinata, Z. Patens, Z. longifolia, Z. pennæformis, Z. elegans, Z. Goldiæi, Z. acuta, Z. lævis, Z. Youngii, Z. Feneonis, Z. Mantelli.
Zamites Bechii, Z. Bucklandi, Z. Lagotis, Z. hastata.

Equisetaceæ.

Equisetum Columnare, E. infundibuliforme, E. dubium.
Calamites Suckowii, C. decoratus, C. undulatus, C. ramosus, C. cruciatus, C. Cistii, C. dubius, C. cannæformis, C. Pachyderma, C. nudosus, C. approximatus, C. Steinhauri, C. radiatus, C. Voltzii, and species not determined.

Filices.

Pachypteris lanceolata, P. ovata.
Pecopteris Reglia, P. Desnoyersi, P. Polypodioides, P. denticulata, P. Phillipsii, P. Whitbiensis, P. Blechnoides, P. Candolliana, P. cyathia, P. arborescens, P. Platorachis, P. polymorpha, P. Oreopterides, P. Bucklandi, P. aspera, and 34 other species.
Sphænopteris hymonophylloides, S. (?) macrophylla, S. Williamsonis, S. crenulata, S. denticulata, S. furcata, S. elegans, S. stricta, S. artemisiæfolia, S. delicatula, S. dissecta, S. Lineans, S. Brardii, S. trifoliolata, S. Schlotheimii, S. fragilis, and 14 other species.
Neuropteris Gailliardoti, N. acuminata, N. Villiarsii, N. rotundifolia, N. Loshii, N. tenuifolia, N. heterophillia, N. flexuosa, N. gigantea, N. oblongata, N. cordata, N. Schewchzeri, N. angustifolia, N. acutifolia, N. crenulata, N. macrophylla, N. oriculata.
Pteniopteris latifolia, P. Vitata.
Cyclopteris orbicularis, C. trichomanoides, C. obliqua, C. plabellata.
Lonchopteris Dournaisii, L. Mantelli.
Odontopteris Brardii, O. Crenatula, O. minor, O. obtusa, O. Schlotheimii.
Shizopteris anomala.
Sigillaria† punctata, S. apendiculata, S. peltigera, S. lævis, S. canaliculata, S. Cortei, S. elongata, S. reneformis, S. Hipprocrepis, S. Candollii, S. oculata, S. orbiculares, S. tessellata, S. Knorrii, S. elliptica, S. transversalis, and 16 other species.
Carpolithus Mentelli.

Marsilliaceæ.

Sphenophyllum Schlotheimii, Sph. Emarginatum, Sph. truncatum, Sph. dentatum, Sph. quadrefidum, Sph. dissecta.

Lycopodiaceæ.‡

Lycopodites piniformis, L. Gravenhorstii, L. Hæninghausii, L. embricatus, L. phlegmarioides, L. tenuifolius, L. (?) filiciformis, L. (?) affinis, L. Lepidodendron, and several species not determined.
Selaginites patens, S. erectus.
Lepidodendron selaginoides, Lep. Elegans, Lep. Bucklandi, Lep. ophiurus, Lep. rugosum, Lep. Underwoodii, Lep. taxifolium, Lep. insigne, Lep. Sternbergii, Lep. longifolium, Lep. ornatissimum, Lep. tetragonum, Lep. Venosum, Lep. Rodianum, Lep. Cordatum, Lep. Volkmanianum, and 25 other species.
Cardiocarpum majus, C. Pomiari, C. Cordifornie, C. ovatum, C. acutum.

* The Cycadees form the passage from the *palms* to the *ferns.—Sprengel.* The Cycadeæ have great proximity to the ferns.—*Lindley.*

† By referring to vol. i. pp. xvii. to xx. of MM. Lindley and Hutton's *Fossil Flora*, the reader will find a very interesting discussion respecting this description of extinct plant *Sigillaria*, which, together with *Stigmaria*, M. Adol. Brongniart and his reviewer consider as belonging to the *Cryptogamous* class.

‡ Mr. Lyell, in his Glossary, p. 72, gives the following explanation of *Lycopodiaceæ*:—"Plants of an inferior degree of organization to Coniferæ, some of which they very much resemble in foliage; but all recent species are infinitely smaller. Many of the fossil species are as gigantic as recent Coniferæ. Their mode of reproduction is analogous to that of ferns. In England they are called club-mosses."

Stigmaria reticulata, S. Weltheimiana, S. intermedia, S. ficoides, S. tuberculosa, S. rigida, S. minima.

PALMÆ.

Flabellaria borassifolia.
Næggerathia foliosa

CANNÆ.

Cannophyllites Virletii.
Clathraria Lyellii.

MONOCOTYLEDONS OF UNCERTAIN FAMILIES.

Sternbergia angulosa, Sternb. approximata, Sternb. distans.
Poacites equalis, P. striata.
Trigonocarpum Parkinsonii, Tr. næggerathia, Tr. ovatum, Tr. cylindricum.
Musocarpum prismaticum, M. difforma, M. contractum.

VEGETABLES OF WHICH THE CLASS IS UNCERTAIN.

Annularia minuta, A. Brevifolia, A. fertilis, A. floribunda, A. longifolia, A. spinulosa, A. radiata. *Asterophyllites** equisetiformis, Ast. rigida, Ast. pygmæa, Ast. hippuroides, Ast. longifolia, Ast. tenuifolia, Ast. delicatula, Ast. Brardii, Ast. diffusa.
Volkmannia polystachya, V. Distachya, V. Erosa.
Dicotyledonous wood, perforated by some boring shell. Cones of Coniferæ. Ferns (?) in Green Sands.

CLASS UNCERTAIN.

Mammalaria Desnoyersii. Many undescribed vegetables, *Lyme Regis*.

CONIFERÆ.

Thuyites divancata, Th. expansa, Th. acutifolia. Th. Cupresiformis.
Taxites podocarpoides.

LILIA.

Bucklandia squamosa.

Being desirous of affording every information, and considering that a degree of cross-examination into the facts of the case may lead to more thorough conviction, I shall, in continuation of the lists now given of FOSSIL PLANTS, as they are grouped together *geologically*, present an abstract list of the same fossils arranged *botanically* by Messrs. Lindley and Hutton. As I shall confine myself to plants found within the same geological range wherein those in the former lists were disimbedded, no genera discovered in formations more recent than the CHALK will be included, a circumstance which will explain the occasional interruption in the numbers of the genera. As regards the apparent discrepancy occasioned by so many being ranged under the *Flowering Classes*, I have only to remit the case for elucidation to a better understanding, and to more perfect means of identifying the fossil fragments.

EXOGENÆ; OR DICOTYLEDONS.

EUPHORBIACEÆ.

? Genus 11. *Stigmaria.* (Variolaria, *Sternb.* Mammillaria, *Ad. Brong.* Ficoidites, *Artis.*)
5 or 6 species in the Coal formation.
1 species (?) in the Oolite.

* No traces of them found among existing vegetables. They are named from the stellated disposition of the leaves round the branches. Buckland's Bridg. Treat. vol. i. p. 479.

Coniferæ.

† Wood only known.

Genus 13. *Pinites.* 3 species in the Coal formation.
Genus 14. *Peuce.* 1 species in the Coal formation; others in the Oolite.
Genus 17. *Taxites.* †† Leaves only known.
1 species in the Oolite.
Genus 19. *Voltzia.* †† Branches, leaves, and fruit known.
4 species in the New Red Sandstone.
Genus 21. *Cupressites.* 1 species in idem.
Genus 23. *Thuytes.* †† Branches only known.
4 species (?) in the shistose Oolite.

††† Doubtful Conifera.

Genus 24. *Brachyphyllum.* 1 species in the lower Oolite.
Genus 25. *Sphenophyllum.* (Rotularia *Sternb.*)
8 species in the Coal formation.

Cycadeæ.

† Leaves only known.

Genus 26. *Cycadites.* 1 species in the Grey Chalk.
Genus 27. **Zamia.* 15 species in the Lias and Oolitic formations.
Genus 28. *Pterophyllum.* 6 species in Marl and Sandstoneof the Lias.
1 species in Quadersandstein.
1 species in the lower Oolite.
Genus 29. *Nilsonia.* 2 species in Sandstone of the Lias.

†† Stems only known.

Genus 30. *Cycadeoideæ.* 2 species in Portland stone.

Dicotyledons of doubtful affinity.

? Genus 31. *Phyllotheca.* 1 species in the Coal formation.
Genus 32. *Annularia.* (Bornia *Sternb.*)
6 or 7 species in the Coal formation.
Genus 33. *Asterophyllites.* (Bruckmannia *Sternb.*)
12 species in the Coal formation.
1 species in Transition beds.

(Obs. This genera is probably an extremely heterogeneous assemblage of all fossils with narrow veinless leaves, not united in a cup at their base.)

Genus 34. *Bechera.* 1 species in the Coal formation.

ENDOGENÆ, OR MONOCOTYLEDONS.

Marantaceæ.

Genus 35. *Cannophyllites* 1 species in recent bed of Coal.

Asphodeleæ.

† Stems only known.

? Genus 36. *Bucklandia.* 1 species in Stonesfield Slate.
Genus 37. *Clathraria.* 1 species in the Green Sand (?)
? Genus 38. *Convallarites.* †† Leaves only known.
2 species in the Variegated Sandstone.

Palmæ.

†† Leaves only known.

Genus 42. *Flabellaria.* 1 species in the Plastic Clay.
1 species in the Coal formation.
Genus 44. *Næggerathia.* 2 species in the Coal measures.
Genus 45. *Zeugophyllites.* 1 species in the Coal formation.

Fluviales.

Genus 47. *Zosterites.* 4 species in Lower Green Sand.
1 species in the Lias (?)

Monocotyledons of doubtful affinity.

† Stems only known.

Genus 51.	*Sternbergia.*	(Columnaria *Sternb.*) 3 species in the Coal formation.

†† Leaves only known.

Genus 52.	*Poacites.*	Several species in the Coal formation.

††† Fruits only known.

Genus 54.	*Trigonocarpum.*	5 species in the Coal measures.
Genus 56.	*Musocarpum.*	2 species in idem.

Flowering Plants of uncertain Class.

Genus 58.	*Æthophyllum.*	1 species in the New Red Sandstone.
Genus 59.	*Echinostachys.*	1 species in idem.
Genus 60.	*Palæoxyris.*	1 species in the New Red Sandstone.

CELLULARES, OR FLOWERLESS PLANTS.

Equisetaceæ.

Genus 61.	**Equisetum.*	2 species in the Lias and Oolite.
		2 species in the Coal formation.
? Genus 62.	*Calamites.*	2 species in Transition beds.
		Several species in the Coal formation.
		4 species in the New Red Sandstone and Coal.

Filices.

Genus 63.	*Pachypteris.*	2 species in Inferior beds of Oolite.
Genus 64.	*Spenopteris.*	1 species in Sand below the Chalk.
		2 species in the New Red Sandstone.
		5 species in the Oolitic formation.
		28 species in the Coal formation.
Genus 65.	*Cyclopteris.*	4 species in the Coal formation.
		1 species in Transition series.
		1 species in the Oolite.
Genus 66.	*Glossopteris.*	2 species in the Coal measures.
		1 species in the Oolite.
		1 species in the Lias.
Genus 67.	*Neuropteris.*	24 species in the Coal formation.
		3 species in the New Red Sandstone.
		2 species in the Muschelkalk, &c.
Genus 68.	*Odontopteris.*	5 species in the Coal measures.
Genus 69.	*Anomopteris.*	1 species in the New Red Sandstone.
Genus 70.	*Tæniopteris.*	3 species in the Lias and Oolite.
Genus 71.	*Pecopteris.*	60 species in the Coal formation.
		10 species in the Oolite.
		2 species in the Lias.
Genus 72.	*Lonchopteris.*	2 species in the Coal formation.
		1 species in the Green Sands.
Genus 73.	*Clathropteris*	1 species in the Lias.
Genus 74.	*Schizopteris.*	1 species in the Coal formation.
Genus 75.	*Filicites.*	1 species in New Red Sandstone.
		2 species in Marl of Lias.
Genus 76.	*Caulopteris.*	1 species in the Coal measures.

Lycopodiaceæ.

Genus 77.	*Lycopodites.*	10 species in the Coal formation.
		3 species in the Oolite, Lias, and Chalk.
Genus 78.	*Selaginites.*	2 species in the Coal formation.
Genus 79.	*Lepidodendron.*	Several species in idem.
Genus 80.	*Ulodendron.*	2 species in idem.
Genus 81.	*Lepidophyllum*	5 species in idem.

Genus 82. *Lepidostrobus.* 5 species in idem.
? Genus 83. *Cardiocarpon.* 5 species in idem.

ALGÆ.

Genus 86. *Confervites.* 2 species in the Chalk Marl.
Genus 87. *Fucoides.* (Agacites *Schloth.*)
4 species in Transition rocks.
7 species in Bituminous Shale.
3 species in the Oolite
11 species in the Chalk.

PLANTS OF UNCERTAIN AFFINITIES.

Genus 88. *Sigillaria.* 40 species in the Coal formation.
Genus 89. *Volkmannia.* 3 species in idem

Notes, referable to the foregoing concentrated lists of fossil vegetable remains, extracted from Professor Buckland's Bridgewater Treatise:—

FILICES, OR FERNS.—The most numerous of the Vascular Cryptogamic plants. The circumstances most favourable to their growth are humidity, shade, and heat. In the Coal formation there are about 120 known species of Ferns, forming about a half of the entire known Flora of this formation; these species represent but a small number of the forms which occur among living Ferns, and nearly all belong to the tribe of Polypodiaceæ, in which tribe are found the greater number of existing arborescent species. The stems of these arborescent Ferns are distinguished by certain peculiarities from those of all *Monocotyledonous* plants.

EQUISETACEÆ.—Well known in this climate as the common Horsetail of our swamps and ditches; reaches from Lapland to the Torrid Zone. Divided (the fossil ones) by Brongniart into *Equiseta* and *Calamites*. The former rare in a fossil state. The latter are characterized by large and simple cylindrical stems, articulated at intervals. Sometimes marked by verticillated branches, and attain to great size. Latitude seems to have had no effect on the size of fossil equisetaceæ (p. 461).

LEPIDODENDRON.—In some points of their structure they have been compared to Conifera; but in other respects, and in their general appearance, with the exception of their great size, they very much resemble *Lycopodiaceæ* or *Club-moss* tribe. Professor Lindley states that the affinities of *existing* Lycopodiaceæ are intermediate between Ferns and Conifera on the one hand, and Ferns and Mosses on the other. They are related to Ferns in the want of several apparatus, and in the abundance of axilar ducts contained in the axis, to *coniferæ* in the aspect of the stems of some of the larger kinds, and to *mosses* in their whole appearance. The internal structure of their stems is intermediate between *Lycopodiaceæ* and *Conifera*. Lindley and Hutton state, that *Lepidodendra* are, after *Calamites*, the most abundant class of fossils in the Coal formations of the North of England,* occurring from twenty to forty-five feet long. By means of *Lepidodendron* a better passage is established from Flowering to Flowerless Plants, than by either *Equisetum* or *Cycas*, or any other genus.

SIGILLARIA.—Plants unknown in modern vegetation, and of which the duration seems to have been limited to the epochs of the Transition period, are dispersed throughout the sandstones and shales that accompany the Coal; colossal; generally filled with sand or clay, and are supposed to have been without any transverse dissepments, and hollow throughout. The bark, which alone remains, probably surrounded an axis composed of soft and perishable pulpy matter, like living equisetaceæ. . . . . M. Brongniart enumerates 42 species of *Sigillaria*, and considers them to have been nearly allied to arborescent *Ferns*, with leaves very small in proportion to the size of the stems, and differently disposed from those of any living *Ferns*.

Lindley and Hutton show strong reasons for considering that *Sigillaria* were Dico-

* Bridgewater Treatise, p. 483, et seq.

tyledonous plants, entirely distinct from Ferns, and different from any plants in the existing system of vegetation.

FAVULARIA, MEGAPHYTON, BOTHRODENDRON, AND ULLODENDRON.—Same group of fossil plants to which the *Sigillaria* belongs—all exhibiting a similar disposition of *scars arranged in vertical rows.* They are separated into the following five families, distinguished by the form of their stems and their scars:—

1. *Sigillaria.* 2. *Favularia.* 3. *Megaphyton.*
4. *Bothrodendron.* 5. *Ullodendron.*

In the three first genera of this group, the scars appear to have given origin to leaves; in the two latter they indicate the insertion of large cones.

STIGMARIA.—An extraordinary family of extinct fossil plants, *stigmaria ficoides*, dome shaped trunk or stem, 3 or 4 feet diameter. Both its surfaces slightly corrugated, and covered with indistinct circular spots, many horizontal branches, varying from 9 to 15, and some of them supposed to have been from 20 to 30 feet long; their leaves have been traced to the length of 3 feet, and have been said to be much longer; the branches are covered with spirally disposed tubercules, resembling the papillæ at the base of the spines of *Echini;* and from each tubercule there proceeded a cylindrical, and probably a succulent leaf. The form of the trunk and branches show that they could not have risen up into the air; but must either have trailed on the ground or floated in water.

ASTEROPHYLLITES.—So called from the stellated disposition of the leaves round the branches, are still more obscure in their nature than the foregoing, and no traces of them are found among existing vegetables, nor in any strata more recent than the Carboniferous series, and many years may elapse before they are understood.

Conclusion respecting the Plants of the Coal Measures.

"The plants which have contributed most largely to the highly interesting and important formation of the Coal, are referable principally to the genera *Calamites*, *Ferns*, *Lycopodiaceæ*, *Sigillareæ*, and *Stigmariæ*. These materials have been collected chiefly from the carboniferous strata of Europe. The same kind of fossil plants are found in the coal mines of North America, and we have reason to believe that similar remains occur in Coal formations of the same epoch under very different latitudes, and in very different quarters of the globe, *e. g.*, in India and New Holland, in Melville Island and Baffin's Bay.

"The most striking conclusion to which the present state of our knowledge has led, respecting the vegetables which gave origin to coal are—1st. That a large proportion of these plants were *vascular cryptogamiæ*, and especially *Ferns;* 2dly. That among the *Cryptogamic* plants, the *Equisetaceæ* attained a gigantic size; 3dly. That *Dicotyledonous* plants, which compose nearly two-thirds of living vegetables, formed but a small portion of the Flora of these early periods; 4thly. That although many extinct genera and certain families have no living representatives, and even ceased to exist after the deposition of the Coal formation, yet they are connected with modern vegetables by common principles of structure, and by details of organization which show them all to be parts of one grand consistent and harmonious whole."*

Sir Henry de la Beche, in his *Manual of Geology*, when treating of the fossil flora, especially those found in the Coal measures, expresses himself thus:—

"We have reason to conclude, that in Poland, Western Germany, Northern France, Belgium, and the British Isles, there were some common causes in operation at the same epoch, producing the envelopment of a great abundance of terrestrial vegetables, of a nature which could not, from the want of the necessary heat, now flourish in the same latitudes. . . . . . The vegetable remains are often of considerable size. M. Brongniart observes, that stems are found in the planes of the strata more than 50 or 60 feet long; and that they may be traced in some of the galleries of the Continental coal mines for more than 40 feet without observing their natural extremity.

* Professor Buckland's Bridgewater Treatise, pp. 479—481.

. . . . . Respecting the general character of the vegetation of that period, M. Brongniart observes, that it is remarkable, 1st. For the considerable proportion of the vascular cryptogamic plants, such as *Equisetaceæ*, *Filices*, *Marsileaceæ*, and *Lycopodiaceæ*; and 2d. For the great development of the vegetables of this class, so that they have attained a magnitude far beyond those of the same class now existing, thus proving that circumstances were particularly favourable to their production during the period under consideration, ... indeed, he concludes, with much apparent probability, that the climates in which the coal plants existed were even warmer than those of our equinoxial regions."*

"When we examine," says MM. De Candolle and Sprengel, "the remains of the primeval world, we find the first traces of vegetable impressions in the slate formations. These remains of the former vegetable world belong almost entirely to the lower families: they consist, for the most part, of *Grasses*, *Reeds*, *Palms*, and *Ferns*, the latter, however, being almost always destitute of fruit. BUT ALTHOUGH THESE FORMS CANNOT BE REFERRED TO ANY ONE OF THE SPECIES WHICH ARE AT PRESENT KNOWN, they have yet so much the appearance of tropical productions, that we are forced to admit a very high degree of heat at the surface of the earth during its former state, which heat must at that time have been diffused over all the zones, because we find the same productions in the slate formation of all parts of the earth.† In order to explain this, it has been supposed, that the plane of the ecliptic, during the former state of the globe, was completely different in its position, and that, consequently, our planet had then another situation with respect to the Sun. But Bode, the worthy veteran of Prussian astronomers, has shown, that the plane of the ecliptic has been for 65,000 years (!!) between the 20th and 27th degree; and that at present it is about about 23 minutes less, and, consequently, the former solution must be entirely abandoned.‡

The following corroborating extracts are of peculiar interest, as they mark Mr. Turner's acquiescence in, and approval of, the information given by those from whom he quotes :—

"That vegetable remains abound in that series of rocks and masses which constitute the Coal formations, is universally agreed. Plants were therefore in being before the coal strata originated; and it is also now the general sentiment that our coals are a transmutation of vegetable matter into that state—an extended mass of mineral peat or turf."§

In a note pertaining to the division of his work, Mr. Turner gives the following interesting information relative to the fossil vegetable remains :—

"M. Ad. Brongniart's tableau, No. 17, gives a long list of them, of which the substance is—'No kind of marine plants; all land ones; Equisetaceæ, Calamites, 12 species. Of Ferns, 21 kinds of Sphænopteris; 2 kinds of Cyclopteris; 11 of Nevropteris; 1 Glossoptera; 46 species of Pecopteris; a Lonchopteris; 5 kinds of Odontopteris; 41 of Sigillaria. Of Marsileaceæ, or the Pepperwort tribe, 7 species. Of the Lycopodiaceæ, 10 species; 2 of Selaginites; and 34 of Lepidodendron; 5 of Lepidophyllum; 4 of Lepidostrobus; 5 of Cardiocarpum; and 8 of Stigmaria; 3 of Palms; a Canna, and 14 species of Monocotyledons.'"||

Mr. Lyell says—

* Manual of Geology, pp. 441—447, 2nd edition, London, 1832.

† It seems, indeed, that all the carbonaceous matter of the more ancient Slate formation ought to be considered as the oldest remains of plants which had been growing, but which had been stopped in their progress; and that all calcareous matter ought to be considered as the remains of a begun but suppressed creation of animal bodies. In what manner mineral substances are formed from corrupting vegetables, we perceive from the production of iron pyrites in our peat mosses, where it is found in layers under the thin, broad, reed leaves, after they have become putrid.

‡ Elements of the Philosophy of Plants, Edin. Trans. pp. 276, 277.

§ M. Marcel de Serres considers the remains of the first period of vegetation to have formed the Coal beds. "They are remarkable for their little variety; for the simplicity of their organization; and for the largeness of their size. They seem to be referable to two chief classes of the vegetable kingdom—to the vascular cryptogames, as the ferns, the horse-tails, and the club-moss tribe; and to the monocotyledons, but of these only a few that resemble palms and arborescent plants."—*Geognosie*, p. 22.

|| Turner's Sacred History, pp. 179—181.

"Between two and three hundred species of plants are now enumerated as belonging to the carboniferous era, and of these a very few only are Dicotyledonous."*

Professor Henslow observes—

"The history of vegetation could not be completed without some enquiry respecting those plants which existed on the earth in its primeval state, during the extended geological epochs which elapsed before the establishment of the present order of things. Traces of this ancient vegetation are very abundant in certain strata, but more especially in the '*Coal measures*,' the important mineral combustible obtained from them being nothing else than vegetable matter in an altered and fossilized state. In general, we do not find the remains of plants so perfectly preserved as the skeletons of vertebrate animals, or the testaceous coverings of mollusca. It is also rare to meet with those parts (the flower and seeds) upon which the distinction of species and their classification chiefly depend, but still the fragments which remain often possess very great beauty; and many specimens of wood are so exactly preserved, that their tissue may be distinguished under a microscope as completely as in recent species. As it is principally from these fragments of stems, and the impressions of leaves, that any comparison between the ancient and present flora of our planet must be instituted, it will be evident that such data must generally be far too imperfect to admit of any accurate determination of specific differences, though they may afford us sufficient materials for ascertaining several truths of high interest. The class, order, sometimes the precise genus, may be ascertained to which a fossil vegetable belongs, even though we possess only a small fragment of the plant. More frequently, these fossils bear an analogy to some recent genera, which they closely resemble, but to which they cannot be accurately referred. In such cases this resemblance is indicated by referring them provisionally to a genus whose name is a modification of the recent genus: thus '*Lycopodites*' is a genus of fossil plants allied to '*Lycopodium*,' but too imperfectly known to have its characters fully pointed out.

"It was soon remarked, when the study of fossil vegetables began to attract the attention of botanists, that those from the coal measures were distinct from the plants now existing on the surface of the earth, and that they more nearly resembled the species of tropical climates than such as grew in the temperate zones. Subsequent researches have shown that the species embedded in different strata likewise differ from each other, and that on the whole there are about fourteen distinct geological formations in which traces of vegetables occur. According to Mons. Brongniart, they first appear in the shists and limestones below the coal. These contain a few *Cryptogamic* species (about thirteen), of which four are marine algæ, and the rest ferns, or the allied orders. In the coal itself above 300 distinct species have been recognised, among which those of the higher tribes of *cryptogamic* plants are the most abundant, amounting to about two-thirds of the whole. Many of them are arborescent, and parts of their trunks are found standing vertically in the spots where they grew. There are no marine plants in this formation. A few palms and graminæ are the chief Monocotyledons; and there are several Dicotyledons which have been considered analogous to Apocynæ, Euphorbaciæ, Cactæ, Coniferæ, &c. . . . . . . The great predominance and size of arborescent ferns and other tribes of Ductalosæ constitute the main feature of the formation.

"Above the Coal we arrive at the New Red Sandstone; in some of the formations subordinate to this series, a few species of fossil plants occur. In the Oolitic series they become more abundant, and some beds are remarkably characterised by the prevalence of the genus *Zamia*, together with some *Coniferæ*, *Liliaceæ*, and many *Ferns*, the latter being very distinct from those in the former formations. In the Green Sandstone and Chalk few species have been hitherto found, and these are almost all marine. Among the Tertiary strata (or those above the Chalk) the *Dicotyledons* begin to prevail to a far greater extent than they did before, and the plants are entirely different, including terrestrial lacustrine, and marine species. Several fruits are referable to existing genera, as Acer, Inglans, Salix, Ulmus, Cocos, Pinus, &c.

"It is remarkable that scarcely any species has been found in more than one distinct formation, and none has occurred in any two which are separated by a long epoch. Hence it appears to be a natural conclusion, that there have been successive destructions and creations of distinct species. . . . .

"Judging from analogy, from the characters, and relative proportions of the species

* Principles of Geology, vol. i. p. 169.

in different classes, the temperature of those parts in which the plants of the first period were growing, must have been both hotter and moister than the climate in any part of the earth at present. It has been plausibly conjectured that the atmosphere was more charged with carbonic acid at those early periods of our planet's history, when gigantic species of cryptogamic plants formed the main feature of its vegetation. . . . . . Since the fossil plants, which have been found in the arctic regions, are analogous to those which now grow in tropical islands, it seems likely, that not only must they have enjoyed a higher temperature, but also a more equable diffusion of light than those regions now possess."*

NATURAL ORDERS OF PLANTS.

List of the Natural Orders of Plants, given by MM. de Candolle and Sprengel, in the "Elements of the Philosophy of Plants," pp. 138—142.

I. Plants of a cellular structure. Scarcely proper seeds. Propagated by Sporæ.

Fam. 1.	Fungi	*a* Conyomici	*d* Gastromyci
		b Nematomyci	*e* Spongiæ
		c Goniomyci	*f* Myeolomyci
„ 2.	Lichens	5. Musci Hepatici	True seeds, double sexual parts
„ 3.	Algæ	6. Musci Frondosi	Ditto
„ 4.	Homallophyllæ		

II. Plants with spiral vessels and slits. True Seeds. The sexual parts not double.

Fam. 7.	Filices	
„ 8.	Pteroidæ	
„ 9.	Lycopodeæ	Uncommon sexual parts
„ 10.	Rhizosperme	Ditto
„ 11.	Naiadæ	

III. Plants with sexual parts obvious, and of the usual form. The spiral vessels dispersed through the stem. The embryon unevolved in the albuminous substance. The number three prevailing.

Fam. 12. Aroidæ
„ 13. Cyperoidæ
„ 14. Grasses
„ 15. Restiaceæ and Junceæ
„ 16. Palmæ
„ 17. Sarmentaceæ (Dioscoreæ, Smilacinæ)
„ 18. Coronariæ (Liliaceæ, Amarillideæ)
Fam. 19. Irideæ
„ 20. Hydrocharideæ
„ 21. Alismeæ
„ 22. Scilamineæ
„ 23. Orchideæ
„ 24. Museæ

IV. Plants with sexual parts obvious, and of the usual form. Spiral vessels in concentric rings. The embryon more or less evolved. Numerical proportion variable.

A. Simple floral cover.

FAMILY.	FAMILY.	FAMILY.
25. Stylideæ	31. Pipereæ	37. Laurineæ
26. Aristolochiæ	32. Strobiliferæ	38. Myristiceæ
27. Polygoneæ	33. Amentaceæ	39. Plantagineæ
28. Chenopodeæ	34. Urticeæ	40. Nictaginæ
29. Santaleæ	35. Fricoceæ	
30. Thymeleæ	36. Protraceæ	

* Botany, in Cab. Cyc. pp. 310—313. Also the authority for the 36th Theorem.

B. Double floral cover. Number five prevailing.

a Petals united.

FAMILY.	FAMILY.	FAMILY.
41. Primuleæ	49. Convolvuleæ	57. Compositæ
42. Personatæ.	50. Jasmineæ	58. Aggregatæ
43. Acantheæ	51. Gentianeæ	59. Valerianeæ
44. Bignoniæ	52. Contortæ	60. Cucurbitaceæ
45. Viticeæ	53. Sapoteæ	61. Passifloreæ
46. Labiatæ	54. Styraceæ	62. Caprifoliæ
47. Asperifoliæ	55. Ericeæ	
48. Solaneæ	56. Campanuleæ	

b Petals more or less free.

FAMILY.	FAMILY.	FAMILY.
63. Rhodondendreæ	79. Ahorneæ	95. Dilleniæ
64. Epacrideæ	80. Sapindeæ	96. Tiliaceæ
65. Labeliæ	81. Onagræ	97. Hermaniriæ
66. Rubiaceæ	82. Salicariæ	98. Chlanaceæ
67. Umbelliferæ	83. Cruciferæ	99. Cisteæ
68. Saxifrageæ	84. Papavereæ	100. Resedeæ
69. Terebinthaceæ	85. Ranunculeæ	101. Ionidiæ
70. Rhumneæ	86. Polygaleæ	102. Caryophylleæ
71. Diosmeæ	87. Leguminoseæ	103. Portubaceæ
72. Berberideæ	88. Cappardeæ	104. Aizoidæ
73. Rutaceæ	89. Gyttiferæ	105. Cereæ
74. Memispermeæ	90. Agrumæ	106. Loaseæ
75. Anoneæ	91. Geraniceæ	107. Myrteæ
76. Magnoliæ	92. Malvaceæ	108. Sedæ
77. Melæ	93. Buthnereæ	109. Melastomeæ
78. Malpighiæ	94. Ochneæ	110. Rosaceæ

THE ANIMAL KINGDOM.

The following is a Synoptic Table of the Animal Kingdom, according to the classification of the late lamented Baron Cuvier :—

ANIMALS, arranged in Four DIVISIONS, Nineteen CLASSES, and Seventy-seven Orders.

- **Division I.—VERTEBRATA;** arranged in Four Classes, and Twenty-seven Orders.
  - **Class I.—MAMMALIA,** including Nine Orders.
    - Order I. Bimana
    - " II. Quadrumana
    - " III. Carnivora
    - " IV. Rodentia
    - " V. Edentata
    - " VI. Pachyderma
    - " VII. Ruminantia
    - " VIII. Cetacea
    - " IX. Marsupiata
  - **Class II.—AVES,** including Six Orders.
    - " I. Rapaces
    - " II. Passeres
    - " III. Scansores
    - " IV. Gallinæ
    - " V. Grallæ
    - " VI. Palmipedes
  - **Class III.—REPTILIA,** including Four Orders.
    - " I. Chelonia
    - " II. Sauria
    - " III. Ophidia
    - " IV. Batrachia
  - **Class IV.—PISCES,** including Two Series.
    - Series I. Osseous, including 6 Orders. — Malacopterygii
      - " I. Acanthopterygii
      - " II. Abdominales
      - " III. Sub-brachiati
      - " IV. Apodes
      - " V. Lophobranchii
      - " VI. Plectognathii
    - Series II. Cartilaginous, or Chondropterygii, including 3 Orders. — Branchiæ fixed
      - " VII. Sturiones
      - " VIII. Selachii
      - " IX. Cyclostomi
- **Division II.—MOLLUSCA;** arranged in Six Classes, and Fifteen Orders.
  - **Class I.—CEPHALOPODA.**
    - " Cephalopoda
  - **Class II.—PTEROPODA.**
    - " Pteropoda
  - **Class III.—GASTEROPODA,** including Nine Orders.
    - " I. Pulmonia
    - " II. Nudibranchia
    - " III. Inferobranchia
    - " IV. Tectibranchia
    - " V. Heteropoda
    - " VI. Pectinibranchia
    - " VII. Tubilibranchia
    - " VIII. Scutibranchia
    - " IX. Cyclobranchia
  - **Class IV.—ACEPHALA,** including Two Orders.
    - " I. Testacea
    - " II. Acephala
  - **Class V.—BRANCHIOPODA.**
    - " Branchiopoda
  - **Class VI.—CIRRHOPODA.**
    - " Cirrhopoda

THE ANIMAL KINGDOM.—Continued.

ANIMALS—(Continued), arranged in Four DIVISIONS, Nineteen CLASSES, and Seventy-seven Orders.

Division III.—ARTICULATA; arranged in Four Classes, and Twenty-four Orders.	Class I.—ANNELIDA, including Three Orders.		Order I. Tubicola
			" II. Dorsibranchia
			" III. Abranchia
	Class II. CRUSTACEA. divided into two Sections.	Section I. Malacostracia, divided into 5 Orders: Compound eyes placed on pedicles and moveable.	" I. Decapoda
			" II. Stomapoda
		Eyes sessile and immovable.	" III. Amphipoda
			" IV. Læmodipoda
			" V. Isopoda
		Section II. Entomostrachia, divided into 2 Orders.	" VI. Branchiopoda
			" VII. Pœcilopoda
	Class III.—ARACHNIDA, including Two Orders.		" I. Pulmonata
			" II. Trachearia
	Class IV.—INSECTA, including Twelve Orders.		" I. Myriapoda
			" II. Thysanoura
			" III. Parasita
			" IV. Suctoria
			" V. Coleoptera
			" VI. Orthoptera
			" VII. Hemiptera
			" VIII. Neuroptera
			" IX. Hymenoptera
			" X. Lepidoptera
			" XI. Rhipiptera
			" XII. Diptera
Div. IV.—RADIATA; arranged in Five Classes, and Eleven Orders.	Class I.—ECHINODERMA, including Two Orders.		" I. Pedicellata
			" II. Echinoderma
	Class II.—INTESTINA, including Two Orders.		" I. Cavitaria
			" II. Parenchyma
	Class III.—ACALEPHA, including Two Orders.		" I. Acalepha simple
			" II. Hydrostatica
	Class IV.—POLYPI, including Three Orders.		" I. Actinia
			" II. Gelatinosa
			" III. Corallina
	Class V.—INFUSORIA, including Two Orders.		" I. Rotifera
			" II. Homogenea

GLOSSARY OF SCIENTIFIC TERMS.

A.

Acephalous.—A κεφαλη without a head, many genera of bivalves, and some mollusca, are acephalous.

Alga, pl. Algæ.—All sea weeds, of cryptogamic class (an order).

Alluvium, Alluvion, and Alluvial (adj.)—Matter transported by rivers where not permanently submersed.

Ammonite.—From the resemblance to horns on statues of Jupiter Ammon. Chambered shell found in secondary, but not as yet in tertiary formations.

Amorphous.—A μορφη: bodies devoid of regular form.

Anaplothera, Anaplotherium.—Fos. order pachydermata, resembling a pig, from ανοπλος, unarmed, and θηριον, wild beast.

Anthracite.—From ανθραξ, coal.

Anthracotherium, or Pachydermata. — From ανθραξ and θηριον.

Anticlinal axis.—The line which passes between two ranges which dip in opposite directions.

Apulmonic.—Without lungs, or corresponding viscera for aerating the blood.

Augite.—A simple mineral of a dark green or black colour, volcanic tendency.

Arenaceous.—Sandy, composed of sand.

Arundinaceous.—Reedy, or reed shaped.

Atoll.—A word used to designate the distinct circular cluster of coral islets, each circular in its turn, and the whole forming a chain of coral islands, such as the Maldivas.

Acrogenous.—In botany is confined to the acotyledonous or cryptogamous plants.

Alumina.—A simple earth, and chief constituent in the solid parts of the globe. It has the remarkable and unique property of contracting by the action of heat, wherein every other body expands.

Azote.—From α, *without*, and ζωη (Zoe) life, or because it cannot maintain life. It is called by Dr. Ure (p. viii.) the solitary incombustible.

Articulations.—The junctions of the bones of the skeleton.

Androgynous.—Where the male and female faculties of generation are united in the same animal; from ανδρες, a man, and γυνη, a woman.

Amphibious.—Amphi, both, βιος, life.

Acalephæ.—*Acalephe*, a nettle (Medusæ Polypi. Sea anemone, hydra, tubipora, cellularea, flustra, coralline, sponge).

B.

Basalt.—One of the commonest varieties of trap rocks, green or black, composed of augite and felspar: comes from *basal*, an Æthiopian word for iron.

Belemnite.—Extinct genus of Cephalopoda, from βελεμνον, a dart.

Bifurcated.—From *bi*, and *furca*, having two branches.

Boulders.—A provincial term for large blocks of stone.

Breccia (Ital).—A rock composed of angular fragments connected together by lime or other mineral substance.

Batrachia.—Βατραχος, a frog.

C.

Calcareous rock.—Limestone; from *calx*, lime.

Carboniferous.—Usually applied in a technical sense to the lowest group of strata of the secondary rocks.

Cataclysm.—From κατακλυζω, to deluge.

Cephalopoda.—Class of molluscous animals having their organs of motion arranged round the head, κεφαλη and ποδα.

Chloritic Sand.—Green sand, from sand and chlorite, from κλωρος, green.

Conglomerate.—From *con* and *glomera*, to heap, round waterworn fragments, cemented by siliceous, calcareous, or argillaceous cement.

Conifera(æ).—Of pine genus, bearing cones in which the seed is contained.

Crater.—A circular cavity in a volcano, from κρατηρ, cup.

Cretaceous.—Belonging to the chalk.

Crop out.—A mineralogical term to express the rising up or exposure at the surface of a stratum, or series of strata.

Crustacea.—Animals having a shelly coat, lobsters, crabs, and even *trilobites*, according to De la Beche.

Cryptogamia, or Cryptogamic.—Applied to a *class* of plants in which the fructification, or organs of reproduction are concealed, from κρυπτος and γαμος marriage.

Crystals.—In mineralogy, simple minerals; quartz in crystals, is called rock crystal, and other regular forms of minerals, whether clear or opaque, are called crystals, from κρυσταλλος, ice.

Culminate.—In astronomy is when a star, &c., comes to its greatest altitude on the meridian. All celestial objects within the circle of perpetual apparition have their upper and lower culminations in every diurnal revolution, once above and once below their respective poles.

Conformable strata.—Strata are termed conformable when their general planes are parallel to each other, or unconformable when they do not do so.

Cotyledons.—In botany, is applied to the seed lobes, which, on germination, turn into leaves.
Cellular.—Consisting of little cells or cavities.
Coprolites.—From κοπρος, dung, and λιθος, a stone, is the name given by Mr. Buckland to the fossil dung of the gigantic and monstrous animals the plesiosaurus and the megalasaurus.
Chelliferous.—Bearing claws like a crab.

D.

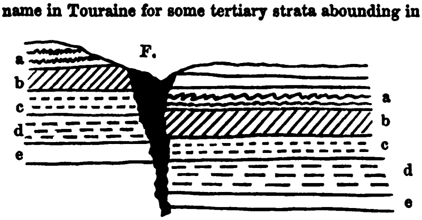
Debacle.—A great rush of waters, carrying rocks and all before it. From *Debacler*, French.
Delta.—The triangular land at river mouths, from the Greek Δ.
Dicotyledonous.—A grand division of the vegetable kingdom, from two cotyledons or seed lobes.
Dikes.—A mass of unstratified, or igneous rock, *granite, trap*, or *lava*, cuts the strata, and rises like a *dike;* difference between veins and dikes somewhat difficult to express, but *dikes* are generally larger, and sides parallel for considerable distances, whereas veins have ramifications, and thin off into slender threads.
Diluvium.—The gravel, &c., of a diluvial wave, or deluge, sweeping over the earth.
Dip.—The point towards which the strata sinks is called its dip, and its angle with the horizon is the angle of dip or inclination.
Dunes.—Sand hills, from *dun* or *dune*, Anglo-Saxon for hill.
Dynamics.—Comes from Δυναμεις, the name applied by Ctesibius and Hero to the five mechanical forces or levers which they established. (Playfair, vol. ii. p. 61.)
Dynamical.—The result of force or power by leverage.

E.

Earth's Crust.—Such superficial parts of our planet as are accessible to human observation.
Exogenous.—In botany is applied to trees which augment both in height and diameter by cone after cone of ligneous matter being added, between the bark and the wood, to the trunk, so that a transverse section at the base will cut through a greater number of concentric layers, than if a similar section were made nearer the top. All the Dicotyledonous trees, or the more perfect division are exogenous—derived from their adding their layers to the outside of the wood.
Endogenous.—Are the monocotyledonous trees which do not increase by adding successive layers between the bark and the wood, but shoot up longitudinally from within the trunk, by adding layers successively *within* the *wood*, and hence the term *en*dogenous.
Entomology. — From εντομα, an insect, and λογος, a discourse.
Edentata.—Toothless.
Echinodermata.—*Echinos*, a hedgehog, *derma*, the skin. Star fish, sea urchin.
Exility.—Rarity, tenuity.

F.

Faluns.—A name in Touraine for some tertiary strata abounding in shells like the Norfolk and Suffolk *crag*.
Fault.—



The fissure at F. is generally filled with broken stone, clay, &c.

Fauna.—The various kinds of animals peculiar to a country constitute its *fauna;* from *Fauni*, the rural deities in Roman mythology.
Flora.—The various kinds of trees and plants found in any country constitute the flora in botanical language.
Fluviatile.—Belonging to a river, from fluvius.
Formation.—A group, whether alluvial deposits, sedimentary strata, or igneous rocks, referred to a common origin or period.
Fossil.—Now restricted to remains of animals and plants found buried in the earth; from *fossilis*, anything that may be dug out of the earth.
Furcatus.—Fork-shaped, in fossil plants.
Fissile.—Having the grain in such a direction as to be easily cleft.

G.

Galena.—Metallic ore, composed of lead and sulphur, γαλεω, to shine.
Gault.—A provincial term for a series of beds of (blue ?) clay and marl, situated between the upper and lower green sand.
Geology.—Relating to the mineral formations of the earth; from γεα and λογος.
Geognosy.—In reality the same as the foregoing, but it has been conventionally restricted to the *descriptions of the structure of the earth*; from γεα and γινωσκω, to know.
Gneiss.—A stratified primary rock, same materials as granite, though usually with a greater proportion of mica, and of a laminated texture, that is, in plates.—German.
Gramineæ.—An order of plants to which grasses belong.
Granite.—Unstratified or igneous rock, inferior to or associated with the oldest stratified rocks, sometimes penetrating them in veins and dykes, composed of three simple minerals, felspar, quartz, and mica, and is named from its coarse, granular structure; from *granum*.
Grauwacke.—A German name, the lowest member of the secondary strata; composed of sandstone and slate, and form the chief part of what are termed the *transition* rocks. *Grau*, German for grey.
Greensand.—Beds of sand, sandstone, and limestone, belonging to the cretaceous period; abundance of green or chlorite earth scattered among them, hence their name.
Greenstone.—A variety of trap, composed of hornblende and felspar.
Grit.—A provincialism for a coarse-grained sandstone.
Gypsum.—A mineral compound of lime and sulphuric acid, also called sulphate of lime.
Gypseous.—Of or belonging to gypsum.
Gravitation.—Laplace has determined that the *attractive force or gravity* must be transmitted

50 millions of times quicker than light; and, therefore, may be considered quite instantaneous, and sets aside all attempts to explain it by the intervention of an ether.—(Pop. Encyc. p. xxxiii.)

Galaxy.—From γαλαξ, milk.

H.

Hornblende.—A simple mineral, dark green or black, which enters largely into the composition of several varieties of the trap rocks.

Hydrophytes.—Plants which grow in water; from υδωρ and φυτον (water and plant).

Habitation of a plant.—Signifies, in botany and geology, or botanical geology, in general, the country where a plant grows wild. It is a more general term than the *station* of a plant.

Hydrogen.—From υδωρ, water, and γεννaω, to produce.

I.

Ichthyosaurus.—From ιχθυς and σαυρα; a gigantic fossil marine reptile, intermediate between a crocodile and a fish.

Infusory Animalcules.—Minute living creatures generated in many *infusions*.

Invertebrated animals.—A great division of the animal kingdom, including all those which have *not* a back bone, joints of which are called *vertebræ*, from *Verto*, to turn, mollusca, insecta, vermes, and zoophytes.

Isothermal.—From ισος, equal, and θερμη, heat; such zones of land, ocean, or atmosphere, which have an equal degree of mean annual warmth.

Infusoria.—Monas, Vibrio, Proteus.

K.

Kimmeridge Clay.—A thick bed of clay belonging to the oolite group; from Rimmeridge, in the Isle of Pinbeck, Dorsetshire.

L.

Lacustrine.—Belonging to a lake; from *lacus*.

Laminæ.—Plates; used in geology for the smaller layers of what a stratum is generally composed.

Land-slip.—Any portion of land which has slid down.

Leucite.—A simple mineral found in volcanic rocks, crystalized, and of a white colour; from λευκος, white.

Lias.—A provincial name, adopted for a particular kind of *limestone*, and being characterized by peculiar fossils, is formed into a particular group of strata.

Lignite.—Wood converted into a kind of coal.

Littoral —Belonging to the sea shore.

Loam.—A mixture of sand and clay.

Lithological.—The stony structure or character of a mineral mass. The lithological character of a stratum is used to distinguish from its zoological character.

Lithophagi.—Molluscus animals which bore into solid stones; from λιθος and φαγειν, to eat.

Lycopodiaceæ.—Plants of an inferior degree of organization to Coniferæ.

Lava.—That which is ejected from an active volcano. The mineral felspar forms more than one-half the mass of *modern* lavas; when in great excess lavas are called *trachytic*, when angite (or pyroxene) predominates, they are termed *basaltic*.

M.

Madrepore.—A genus of corals, but generally applied to all the corals distinguished by superficial star-shaped cavities. There are several fossil species.

Magnesian Limestone.—An extensive series of beds lying in geological position immediately above the coal measures, so called because they contain much of the earth of magnesia as a constituent part.

Mammoth.—Fossil elephant (E. primigenius), from a Tartar word, to burrow under ground.

Marl.—A mixture of clay and lime, usually soft, but sometimes hard, in which case it is called indurated marl.

Marsupial Animals.—A tribe of animals having an exterior sack or pouch; from *marsupium*, a purse.

Mastodon.—A genus of fossil extinct quadrupeds, allied to the elephant; from μαστος, mammilla, and οδων, tooth; teeth having conical mammillary crests.

Mechanical Origin (Rocks of).—When rocks are composed of sand, pebbles, or fragments, to distinguish them from those of an uniform crystaline texture, which are of *chemical* origin.

Megalosaurus.—A fossil gigantic amphibious animal, of the Saurian or lizard and crocodile tribe; from μεγαλησ and αυρα.

Megatherium.—A fossil extinct quadruped, resembling a gigantic sloth; from μεγα and θηριον.

Metamorphic Rocks.—Another term for the stratified primary rocks, and referring more particularly to the *altered* stratified rocks of that group; from μετα, trans, and μορφη, form.

Mica.—A simple mineral, having a shining silvery surface, and capable of being split into very thin leaves, commonly called *talc*; the brilliant scales in granite are mica; from *mico*, to shine.

Mica Slate, Mica Schist, Micaceous Schistus.—One of the lowest of the stratified rocks, belonging to the primary class, which is characterized by being composed of a large proportion of mica united with quartz.

Mollusca, Molluscous Animals.—Animals such as shell fish, which, being devoid of bones, have soft bodies; from *mollis*, soft.

Monocotyledonous.—A grand division of the vegetable kingdom, founded on the plant having only one cotyledon, or seed lobe; μονος, single.

Mountain Limestone.—A series of limestone strata, of which the geological position is immediately below the coal measures, and with which they also sometimes alternate; grey, compact, and crystaline (marine).

Muriate of Soda.—Scientific name for common salt.

Muschelkalk.—A limestone which, in geological position, belongs to the red sandstone group. This formation is not yet found in England, and the German name is adopted by English geologists; from *muschel*, shell, and *kalkstein*, limestone.

Mollusca.—According to Dr. Fleming, contains:

Order I.—Mollusca Cephala	Sect.	1.—Natantia.
		2.—Gasteropoda.
II.—Mollusca Acephala	Sect.	1.—Conchifera.
		2.—Bivalvia.
		3.—Tunicata.
III.—Nautilidæ	Part.	1.—Chambers with simple margins.
		2.—Chambers with waved margins.

Mosaic Week.—The first week—that mentioned, day by day, in the 1st Chapter of Genesis.

N.

New Red Sandstone.—A series of sandy, argillaceous, and often calcareous strata; predominant colour, brick red, but having portions of a greenish grey, in spots and stripes, so that the formation has been also called the variegated

sandstone. The European formation, so called, lies in a geological position immediately above the coal measures.

Nodule.—A rounded, irregular shaped lump or mass; from *nodus*, knob.

Nucleus.—A solid, central piece, round which other matter is collected; from *nucleus*, kernel.

Nummulites.—An extinct genus of the order of molluscous animals, called Cephalopoda, of a thin, lenticular shape, internally divided into small chambers; from *nummus*, coin, and λιθος, from resembling a coin.

Nudosus.—A term of fossil botany, means bare, stripped.

O.

Obsidian.—A species of lava, very like common bottle glass; pumice-stone is obsidian in a frothy state.

Old Red Sandstone.—A stratified rock belonging to the carboniferous group.

Oolite, or Oolitic.—A limestone forming a characteristic feature of a group of the secondary strata; named from resemblance to fish-roe, and comes from ωον, egg, and λιθος, stone.

Ophidious reptiles.—The serpent family; οφις, a serpent.

Orthocerata.—An extinct genera of cephalopoda; from ορθος and κερας.

Osseous Breccia.—From *osseus*, bony.

Outliers.—A portion of detached strata, at some distance from the general mass; adopted in geology.

Oxide.—The combination of a metal with oxygen.

Oxygen.—From οξυς, sour, and γενναω, I form, or the formation of acid. Three cubic inches of oxygen is calculated to be equal to 1 grain, or 1 cubic inch = 1-3rd of a grain.

P.

Pachydermata.—An order of quadrupeds, elephants, rhinoceros, horse, pig, &c., from having thick skins; παχυς, thick, and δερμα, hide.

Palæotherium, and Palæothere.—A fossil extinct quadruped, belonging to the order παχηδερματα; from παλαιος, ancient, &c.

Petroleum.—A liquid mineral pitch, so called because it is seen to ooze, like oil, out of a rock.

Phanerogamic Plants.—Linnæian name for those plants whose reproductive organs are apparent; from φανερος, evident, and γαμος, marriage.

Physics.—From φυσις, nature. The properties of natural bodies, laws of motion, &c., sometimes called natural philosophy, and mechanical philosophy.

Phytophagus.—Plant eating; φυτον and φαγειν.

Pteris.—A common termination for all plants of the fern tribe, in fossil botany.

Pitchstone.—A rock of an uniform texture, volcanic class, having an unctious appearance, like indurated pitch.

Plastic Clay.—One of the beds of the eocene tertiary period, so called because used in making pottery; πλασσω, to form or fashion.

Plesiosaurus.—From πλησιον, near to, and σαυρα, lizard.

Plutonic Rocks.—The primary, unstratified, crystaline rocks have been very commonly called *plutonic*, from the opinion that they were formed by igneous action at *great depths*, whereas the *volcanic*, though they also have risen up from below, have cooled upon or near the surface.

Polyparia.—Corals, a numerous class of invertebrated animals, belonging to a great division called Radiaria, or Radiata.

Porphyry.—An unstratified igneous rock, term as old as Pliny; from πορφυρα, pimple.

Pinnated.—Feathered, like an arrow.

Primary Rocks.—Are divisible into two groups, the stratified and the unstratified. The stratified consist of gneiss, mica-schist, argillaceous schist, or clay-slate, hornblende schist, primary limestone, and others. The unstratified or *plutonic* is composed in a great measure of granite, and others closely allied to granite. Both these groups agree in having, for the most part, a highly crystaline texture, and in not containing organic remains.

Productæ.—An extinct genus of bivalve fossil shells, occurring only in the older of the secondary rocks; it is closely allied to the living genus, Terebratula.

Purbeck Limestone, Purbeck Beds.—Belonging to the Wealden group.

Pyrites (Iron).—A compound of sulphur and iron, yellow and shining like brass, and found in almost every rock, stratified and unstratified; in common roofing slate it is very prevalent.

Phosphorus. — From φως, light, &c.

Pressure.—It is estimated, by Sir James Hall, that it would require a pressure equal to about 1700 feet of sea water, equivalent to the pressure of a column of lava 600 feet high, to prevent the carbonic acid gas from being driven off in forming a heated mass of volcanic rock into *basalt*.

Planet.—From πλανητης, a wanderer.

Phytivorous.—From φυτον, a plant, and *voro*, to *devour*.

Parallax.—May be generally defined as the change of apparent situation of any object arising from a change of real situation of the observer.—(Herschel's Astron. p. 180.) But it also has a more technical meaning.

Passeres.—*Passer*, a sparrow (lark, thrush, swallow, crow, wren).

Pliosaurus.—πλεσιον, *near to*; Sauria, a reptile.

Protorotation.—The first revolution of the earth, or other heavenly body, around its axis, which took place on the *first* day of the Mosaic week, more especially applied to the first diurnal motion of the earth.

Q.

Quadrumana.—Order of mammalious animals to which apes belong; from *quadrus*, and *manus*, their feet being as hands.

Qua-qua-versal dip.—The dip of beds to all points of the compass around a centre, as in the case of beds of lava round the κρατηρ of a volcano; from *qua-qua-versum*, on every side.

Quartz.—A German provincial term universally adopted for a simple mineral composed of pure silex, or earth of flints,—rock crystal is an example.

R.

Red Marl.—A term often applied to the new red sandstone, which is the principal member of the red sandstone group.

Rock Salt.—Common salt, or muriate of soda, found in vast solid masses or beds in different formations, extensively in the new red sandstone formation.

Ruminantia.—Animals which ruminate or chew the cud.

Recent.—In geological language is applied by Mr. Lyell to the period and productions on the earth, which have originated since it was tenanted by man, whether they be sedimentary deposits, volcanic rocks, organic or inorganic

remains; provided they are coeval or subsequent to this period, they are termed *recent*; they may even be *extinct*, like the Dodo, the only case.

Radiata.—One of the subdivisions, according to Dr. Fleming, of the invertebrate animals, and is again divided into echinodermata, acephala, zoophyta, and infusoria.

Respiration.—Under ordinary circumstances, a man consumes, on an average, about 45,000 cubic inches, or 15,000 grains of oxygen in 24 hours.—Mason Good, vol. i. p. 513.

S.

Saccharoid, Saccharine.—When a stone has a texture resembling that of loaf sugar; from σακκαρ and ειδος.

Saliferous.—Yielding salt.

Sandstone.—Any stone composed of an agglutination of grains of sand, whether *calcareous* or *siliceous*.

Saurian.—Any animal of the lizard tribe; from σαυρα.

Schist.—Synonymous with slate; from *scindo*, to split.

Schistose Rocks.—Synonymous with slaty rocks.

Scoriæ.—Volcanic cinders. Latin.

Seams.—Thin layers which separate two strata of greater magnitude.

Secondary Strata.—An extensive series of the stratified rocks which compose the crust of the globe, with certain characters in common, which distinguish them from another series below them called *primary*, and from a third series above them called *tertiary*.

Sedimentary Rocks.—Are those which have been formed by their materials having been thrown down from a state of suspension or solution in water.

Selenite.—Crystalized gypsum, or sulphate of lime, a simple mineral.

Serpentine.—Contains much magnesian earth, and derives its name from sometimes being like the skin of a serpent; it is for the most part unstratified, but it is sometimes found among the stratified metamorphic rocks.

Shale.—A provincial term, meaning slaty clay.

Silex and Silica.—One of the pure earths; Latin for flint. The French geologists have applied it as a generic term for all minerals composed entirely of silex, of which there are many of different external forms.

Silicate.—A chemical compound of silica and another substance, such as iron.

Silt.—The deposition from a river, &c.—mud, &c.

Simple Mineral.—Individual mineral substances, as distinguished from rocks which are generally an aggregation of them. They are not simple, however, in regard to chemical analysis; pyrites, for instance, in geology is a simple mineral, although a chemical compound of sulphur and iron.

Sporules.—The reproductory corpuscula (minute bodies) of cryptogamic plants; derived from σπορα, seed; they have neither corculum, rostellum, nor plumula, but shoot out and germinate from every joint.

Stalactite.—When water holding lime in solution drops it from the roof of a cavern, those encrustations, like icicles, which hang down, are stalactites; from σταλαζω, to drop.

Stalagmite.—The crust on the floor of a cavern from the above, which is composed of layers of limestone; from σταλαγμα, a drop.

Stilbite.—A white crystalized simple mineral, of a dullish lustre, one of the zeolites, in trap.

Stratum, Stratified, Stratification.—The two latter words are inflexions of the former, which denotes rocks that lie on one another like the leaves of a book; from *Stratum*, to strew, or lay out.

Strike.—The direction or line of bearing of strata which is always at right angles to their prevailing dip.

Subapennines.—Low hills at the foot of the great chain of the Appenines; older pliocene period.

Syenite.—A kind of granite, so called from being brought from Syene, in Egypt.

Sessile.—In botany, that which grows or spreads out horizontally, without attaining any height, sitting on the seed without foot stalk, such as the common grasses.—And can be sat upon. From *Sessilis, e.*

Species, A.—"Every collection of similar individuals, produced by other individuals like themselves."—Lamark.

"A species comprehends all the individuals which descend from each other, or from a common parentage, and those which resemble them as much as they do each other."—Cuvierian Theory of the Earth, p. 116.

Station of Plants.—In botany and geology signifies the peculiar nature of the locality where each species is accustomed to grow, and has reference to climate, soil, humidity, light, elevation above the sea, and is different from its *habitation*.

Seed-lobes (or Seed of Plants).—Are composed of cotyledons which, on germination, turn into leaves, and of a corculum, consisting of *plumula*, which becomes the stem, and of *rostellum*, which descends and becomes the roots.

Synthesis.—From συν, together, θεσις, of, and τιθημι, I put, or I put together.

Syphon.—A simple hydraulic instrument in the form of a curved tube, from which, the air being extracted, and one end immersed in a liquid, the atmospheric pressure causes the liquid to run through as if pumped continuously.

T.

Talus.—When fragments are broken off by the action of the weather from the face of a steep rock, they form, by their accumulations, *talus* at its foot.

Tertiary Strata.—A series of sedimentary rocks, with characters which distinguish them from the two other great series of strata, the secondary and primary, which lie *beneath* and around them.

Testacea.—Molluscous animals, having a shelly covering. Etym. *testa*, a shell, hellix, murep, buccinum, ostrea, &c.

Thin out.—When a stratum becomes gradually less in thickness, and the two surfaces approach nearer and nearer, and when at last they meet, the stratum is said to *thin out*, or disappear.

Trachyte.—A variety of lava, essentially composed of glassy felspar.

Trap, and Trappean Rocks.—Volcanic rocks composed of felspar, angite, and hornblende; derived from the Swedish word *trappa*, a stair, because, in Sweden, the rocks of this class rise above one another, like the steps in a staircase.

Travertin.—A semi-crystaline calcareous deposit from streams; from Tibur, because found in Anio, near Rome.

Tuff, or Tuffo.—An Italian name for a variety of volcanic rock of an earthy texture, seldom very compact, and composed of an agglutination of fragments of scoriæ and loose matter ejected from volcanoes.

Trass.—In geology is applied to a tuffaceous alluvium of the Rhine, it is unstratified, and has covered large areas, and choked up many vallies; it is very similar to *locss*.

Thohu vel Bohu.—Two Hebrew words used in the 2nd verse, 1st chap. of Genesis, to signify

that the earth was without form and void; *thohu* signifies a thing which has not yet received its form, as the clay of a potter's vessel unformed.—Presbyterian Review, No. XV.

Thehom.—Used in the same place, means literally, a bottomless abyss, and is rendered into Greek by αβυσσος, a boundless place, not in *one* but in all its dimensions, not the *deep* only but the *vast*.—Presbyterian Review, No. XV.

Taxodium Tree.—Celebrated large trees which grow at the bottom of Chepultepee, about four miles from the City of Mexico, and are of the cypress family; are very magnificent (they are the *cupressus disticha* of Linn).

Truncated.—In conchology, maimed, or cut off.

Tentaculæ.—In ditto, feelers.

Tubular.—In ditto, consisting of a pipe or trunk.

Tasselated.—In ditto, marked in a manner resembling dice.

U.

Uranography.—Relating to the stars; astronomy.

V.

Variens.—In fossil botany is applied to plants which indicate having been of various colours.

Vascular.—Consisting of vessels, full of vessels.

Veins.—In mineralogy are fissures filled up with substances differing from the rock, and which may be either earthy or metallic.

Vertebrated Animals.—A great division of the animal kingdom, including all those which are furnished with a back bone. The separate joints are called vertebræ, from *verto*, to turn; mammalia, aves, reptilia, and pisces, are its four classes.

Vesicle.—A small circular enclosed space, like a little bladder; diminutive of *vesica*.

Volcanic Bombs.—Stones thrown from volcanoes, which assume a rounded, and frequently a pear shape.

Volcanic Foci.—The subterranean centres of action in volcanoes, where the heat is supposed to be in the highest degree of energy.

Zeolite.—A family of simple minerals, including stilbite, tresotype, analcime, and some others usually found in trap or volcanic rocks. Some of them swell or boil up when exposed to the common blow-pipe, and hence the name ξεω, to froth, and λιθος, a stone.

Zenith.—Or vertically above the spectator, from an Arabic word so signifying.—Herschel.

Zoology.—The description of the animal kingdom; from ξωον, animal, and λογος.

Zoophytes.—Corals, sponges, and other aquatic animals allied to them, so called because while they are the habitation of animals, they are fixed to the ground, and have the form of plants; ξωον, an animal, φυτον, a plant.

FINIS.

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